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ResTech and the Resolution of Critical Financial Infrastructures: An Application to Central Counterparties

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Working paper No. 93

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Data are now more valuable than ever.
Whoever controls the data will control the future.

Yuval Noah Harari, *Homo Deus*

Abstract

This paper analyses the potential of resolution technology (ResTech) as a strategic tool for improving the planning, execution, and monitoring of central counterparty (CCP) resolution processes. Building on the existing technology ecosystem in the RegTech and SupTech fields, the paper envisages a natural extension of these technologies to critical resolution functions in a context of increasing digitalisation and financial interconnectedness. Through a review of literature and institutional experiences, we identify the most relevant enabling technologies (such as AI, NLP, DLT and digital simulators), their potential applications in the preventive and executive phases, and the associated risks.

The study highlights the need to strengthen institutional capacities, develop secure environments for experimentation, and foster effective international – particularly European – cooperation through bodies such as the Financial Stability Board (FSB) and the European Securities and Markets Authority (ESMA). Finally, the paper proposes action plans to progressively integrate ResTech into operational and regulatory frameworks with the aim of establishing it as a key pillar for the effective, legitimate and appropriate resolution of the challenges in the digital financial system.

Keywords

ResTech, central counterparties (CCPs), CCP resolution, emerging technologies, artificial intelligence, quantum computing, financial supervision, systemic crises, resolution simulation, interoperability, RegTech, SupTech, data governance, cyber resilience, cross-border coordination, regulatory automation, financial stability.

1 Introduction

The digitalisation of the financial system has profoundly transformed its structure, functioning, and risk dynamics. The emergence of new technological players – particularly fintechs – has introduced innovations in areas such as payments, asset management, credit and alternative financing. This has generated a more agile, decentralised and interconnected ecosystem. While these transformations boost efficiency and broaden access to financial services, they also pose new challenges to system stability and the performance of the authorities.

In this context, a number of technological trends have emerged with direct applications in the regulatory and supervisory spheres. RegTech (regulatory technology), which supports financial institutions in regulatory compliance through digital tools, and SupTech (supervisory technology), which provides authorities with advanced capabilities for monitoring, processing large volumes of data, detecting anomalies and improving systemic oversight. Both disciplines address the need to modernise the regulatory and supervisory framework in a context of increasing speed, automation and complexity in financial markets.

Authorities are adopting these technologies not only to improve operational efficiency, but also to better manage new risks, ensure transparency, and strengthen institutional capacity to anticipate and respond to critical situations. The increasing focus of international bodies such as the Financial Stability Board (FSB), the International Organisation of Securities Commissions (IOSCO), the European Central Bank (ECB) and the European Securities and Markets Authority (ESMA) on these tools reflects their strategic potential in the digital age.

In this evolving ecosystem, a new aspect is beginning to emerge: resolution technology. This is defined as the use of advanced digital tools to support resolution authorities in the planning, executing and monitoring interventions against crisis-hit institutions. Although the concept is still under development, it is particularly applicable in operationally complex environments, such as central counterparties (CCPs), where rapid and accurate intervention with full legal certainty is required.

In terms of theoretical development, academic literature on ResTech is scarce and has mostly focused on its possible application to bank resolution. One of the most significant contributions to this field is the work of Loiacono and Rulli (2022), who examine how emerging technologies could transform bank resolution processes, from planning to real-time execution. This approach, although in the early stages, opens the door to extending the analysis to other critical financial infrastructures, such as CCPs.

As Loiacono and Rulli (2022) point out, the resolution of failing financial institutions does not offer direct economic benefits, so technological innovation in this area must be led by the authorities, unlike in the areas of compliance and supervision, where there is some private sector incentive to innovate.

This article analyses the applicability of ResTech to the specific context of CCPs and explores its potential uses, benefits, and limitations. It also provides recommendations aimed at facilitating the progressive and effective integration of ResTech into existing operational frameworks, thereby strengthening institutional preparedness for future crises.

2 Literature reviewed

To prepare this paper, a series of institutional and academic sources were reviewed to analyse the evolution and consolidation of innovative technologies applied to regulatory compliance (RegTech) and supervision (SupTech). In the area of financial institution resolution, the academic literature has begun to explore the potential of these technologies in bank resolution. However, no line of research has yet addressed the application of technological innovation to the resolution of financial market infrastructures, particularly CCPs. This reveals a significant gap in the literature and opens up a relevant area for future research.

At an international level, the FSB has recognised the transformative role of supervisory technologies (SupTech) in enhancing financial oversight. In its 2020 report, the FSB highlights how the adoption of SupTech and RegTech tools is being driven by the increasing availability and granularity of data, as well as advanced technological infrastructures, such as cloud computing and application programming interfaces (APIs). These technologies enable authorities and regulated institutions to manage the growing number of regulatory requirements established after the 2008 financial crisis more efficiently. The report also notes that SupTech has become a strategic priority for many authorities, with an increasing number developing innovation or data strategies since 2016. However, the report also identifies associated risks, such as over-reliance on methods based on historical data, which could lead to incorrect inferences about the future, and the limited transparency of some SupTech and RegTech tools (FSB, 2020).

IOSCO has also recognised the transformative role of SupTech in regulatory capacity building. Through various reports, IOSCO has documented the increasing use of automated tools to address emerging risks, such as greenwashing in sustainable finance, through SupTech solutions capable of analysing large volumes of information and detecting deviations in disclosure practices (IOSCO, 2023a). IOSCO's 2023 annual report emphasises the importance of sharing best practices in regulatory technology and highlights the growing interest among supervisors in integrating artificial intelligence, machine learning, and predictive analytics tools (IOSCO, 2023b). Additionally, its latest thematic report on technological challenges in market surveillance emphasises how authorities are adopting sophisticated monitoring systems to detect market manipulation and other irregularities in real time (IOSCO, 2025a). This effort forms part of a broader institutional strategy that promotes the development of regulatory capacity through digital innovation. This is reflected in the 2025 work programme, which announces specific workshops to share regulatory experiences on SupTech and encourage cross-border cooperation (IOSCO, 2025b).

At the European level, while the European Systemic Risk Board's (ESRB) annual report (ESRB, 2023) does not explicitly focus on the use of technologies in macroprudential oversight, it does include relevant initiatives in areas such as cyber resilience, crypto-asset and decentralised finance monitoring, climate risk analysis, systemic liquidity monitoring, and stress test development, all of which require advanced technological capabilities. These references, albeit indirect, highlight the increasing need to integrate digital tools in identifying and managing systemic risks.

The ECB has also increased its efforts to adopt SupTech to strengthen banking supervision. Through the Single Supervisory Mechanism (SSM), the ECB has implemented training and development programmes for innovative tools incorporating artificial intelligence (AI) and data analytics, with the aim of improving the efficiency and effectiveness of financial oversight (ECB, 2023a and 2023b). These initiatives aim to optimise existing processes and anticipate and mitigate emerging risks in the financial system.

ESMA has played a leading role in promoting and adopting SupTech technologies (ESMA, n.d.). Since 2019, ESMA has documented how regulatory pressure and budgetary constraints have motivated both market participants and supervisors to use AI-based tools, machine learning (ML) and data analytics to improve market surveillance and risk detection (ESMA, 2019). In its Data Strategy 2023-2028, the organisation prioritises strengthening the use of data technologies in oversight to reduce compliance costs for regulated entities and move towards more efficient, data-driven oversight at the European and national levels (ESMA, 2023). Furthermore, ESMA's 2025 Work Programme places the implementation of common SupTech projects and the development of analytical capabilities at the centre of its strategic action as part of an institutional response to the increasing complexity of the financial system (ESMA, 2024).

The Single Resolution Board (SRB) has identified digitalisation as a key priority across all areas of its Strategy 2024-2028 (SRB, 2024). The strategy document emphasises the institution's commitment to enhancing its operational and analytical capabilities by updating its technology strategy. This involves improving data quality, increasing automation, and developing secure digital tools for information exchange. The SRB also intends to explore the potential of emerging technologies, such as digital simulations and collaborative platforms, to enhance the efficiency and effectiveness of resolution processes. This technological commitment responds to the growing need to act quickly, securely, and in a coordinated manner within an increasingly complex and dynamic financial environment.

In the national context, the Banco de España has adopted a proactive approach to technological innovation in banking supervision by incorporating SupTech tools to improve the efficiency and effectiveness of its oversight functions. Its institutional blog highlights its participation in the SSM SupTech initiative, the development of its own tools based on the Central Credit Register (CCR) and the promotion of a culture of innovation and data science training (Banco de España, 2023b). Furthermore, in 2023, the Banco de España underwent an external evaluation of its SupTech function. This evaluation focused on governance of technical and human

development processes, alignment with strategic digitalisation objectives, and coordination with the SSM (Banco de España, 2023a). In its latest supervision report (2025), the Banco de España highlights the growing use of machine learning and automation techniques in supervisory processes, including the evaluation of internal models and climate risk monitoring. These initiatives demonstrate the Banco de España's dedication to integrating innovative technologies into financial oversight, with the aim of enhancing operational efficiency and responsiveness to the growing complexity of financial markets.

The Comisión Nacional del Mercado de Valores (CNMV) has adopted a proactive approach to technological innovation in financial oversight, incorporating SupTech tools to strengthen its supervisory capabilities. Since 2018, the CNMV has used information processing technologies in various supervisory activities, such as regularly analysing atypical investment fund returns, enabling the detection of incidents relevant to financial oversight (CNMV, 2019). The CNMV has also worked on specific projects applying blockchain technology, such as the Fast Track Listing (FTL) project in collaboration with BME and financial institutions. The aim of this project is to simplify and speed up the registration processes for issuing financial instruments (CNMV, 2019). The CNMV has also participated in European initiatives such as the European Financial Transparency Gateway (EFTG), which uses blockchain technology to provide single access to information on securities issues and their issuers (CNMV, 2019). These actions demonstrate the CNMV's dedication to integrating innovative technologies into financial oversight to enhance operational efficiency and responsiveness to the increasing complexity of financial markets.

In line with its commitment to digital transformation, the CNMV's 2024 Annual Report (CNMV, 2025b) highlights that progress has continued to be made in both supervision (SupTech) and resolution (ResTech). In the area of supervision, a new SupTech tool was developed in 2024 to improve the monitoring of Euribor contributions and optimise the efficiency and accuracy of supervisory processes in real time. In the area of resolution, the automation of resolution plans for investment services firms (ISFs) using ResTech tools was notable, as was the implementation of a dashboard specifically designed to assess the resolvability of institutions more dynamically and efficiently. These initiatives demonstrate the CNMV's dedication to leveraging advanced technologies to enhance the effectiveness of its supervisory and resolution functions.

In its *Activity Plan 2025* (CNMV, 2025a), the CNMV further emphasises the importance of digital transformation as a strategic pillar for achieving more agile, efficient, and data-driven oversight. The institution emphasises developing capabilities in both analytical and generative artificial intelligence to optimise processes relating to supervision and risk detection and to improve interaction with investors through virtual assistants. This is accompanied by the modernisation of technological infrastructures, the strengthening of cybersecurity, and the implementation of a data strategy based on quality, security, and information governance. These initiatives address the need to anticipate emerging risks, integrate SupTech tools into day-to-day supervision, and enable real-time, evidence-based decision-making.

From an academic perspective, the study of the SupTech phenomenon has gained prominence in recent years, as financial supervisors have been exploring ways to use advanced technologies to improve efficiency, transparency, and responsiveness to systemic risk. Di Castri, Grasser and Ongwae (2023) provide an overview of this in their State of SupTech Report. Based on surveys of over 60 supervisory authorities, the report highlights that, although most are engaged in SupTech initiatives, only a minority have developed comprehensive strategies. In the same vein, Broeders and Prenio (2018) identify early applications in areas such as automated data collection, fraud analysis and compliance monitoring. Empirically, Degryse, Huylebroek and Van Doornik (2025) document the disciplinary effect of SupTech in the Brazilian banking system, demonstrating that these tools can significantly reduce credit risk-taking. From an institutional perspective, Avramović (2023) analyses the case of UK regulator the FCA and its BLENDER system, demonstrating that SupTech adoption depends on dynamic internal capabilities and structural factors. Conversely, Xia (2024) offers a legal perspective on the regulatory challenges posed by SupTech, emphasising the necessity of adapting traditional legal frameworks to the evolving technological landscape. Taken together, this body of work reveals a consolidating field, with approaches ranging from normative analysis to the empirical assessment of the regulatory impact of monitoring technologies.

Regarding the regulatory challenges posed by the use of artificial intelligence in the financial sector, Crisanto, Leuterio, Prenio and Yong (2024) analyse the current landscape in detail. They highlight operational benefits as well as emerging risks, including model risk, governance, and third-party oversight. The authors emphasise that despite the growing use of AI-based solutions, few financial authorities have developed specific regulatory frameworks, raising significant concerns regarding stability and consumer protection.

The concept of ResTech has begun to emerge in academic literature as a natural extension of SupTech, focusing on the specific functions of planning and executing bank resolutions. In their pioneering work, Loiacono and Rulli (2022) define ResTech as the set of innovative technologies designed to assist resolution authorities in their work during crisis situations. Unlike RegTech and SupTech, which have largely been developed by the private sector and ongoing compliance frameworks, the authors emphasise that ResTech innovation tends to emerge from the public sector due to the low commercial incentive associated with preparing for rare but high-impact resolution events. The study identifies four key functional areas for the development of ResTech: i) resolution planning based on dynamic data and scenario analysis, ii) the technological implementation of resolutions using secure and efficient tools, iii) the exchange of sensitive information between national and international authorities, and iv) post-resolution compliance monitoring. This approach positions ResTech as a strategic tool for improving institutional preparedness, reducing reaction times, and strengthening cross-border coordination in the event of a financial crisis.

Among studies warning of imbalances in learning capacity between public and private actors, Zheng and Caldwell (2008) analysed how private contractors tend to learn faster and more effectively than their public counterparts in complex

public-private partnership projects. The authors refer to this asymmetry in learning processes as 'asymmetric learning', and explain it by structural differences in incentives, organisational flexibility and prior experience. This has important implications for power distribution and project effectiveness. In the financial sphere, the FSB (2017) has warned of similar risks relating to private institutions' early adoption of technologies such as artificial intelligence, which may exceed the authorities' oversight capacity and lead to gaps in understanding, regulatory delays and operational dependencies. Both contributions are particularly relevant for understanding the challenges posed by the incorporation of advanced technologies (ResTech) in the resolution of financial institutions, as the gap between public and private capacities can directly impact the resolution process's effectiveness, independence, and legitimacy.

In the more specific area of CCPs, Cerezetti, Chan and Plata (2024) discuss how AI could disrupt CCP risk management, which has traditionally evolved gradually due to technological, statistical and regulatory advances. The article examines how AI could influence the evolution of risk management in CCPs. Based on an analysis of current risk functions, the article concludes that areas such as credit, custody and investment risk are particularly well-suited to AI-based solutions due to their reliance on large volumes of mostly public, unstructured data. Conversely, critical functions such as market risk management face greater regulatory and technical challenges in implementing AI models, suggesting a more gradual path of automation.

The incorporation of advanced technologies, such as AI, in the financial sector has driven innovation and the need for specific regulation. In this regard, the EU Regulation on Artificial Intelligence (Regulation (EU) 2024/1689) establishes a pioneering legal framework that classifies AI systems according to their level of risk, imposing proportionate requirements to ensure their safe, transparent and fundamental rights-compliant use, especially in sensitive sectors such as finance. Additionally, from a public policy and supervisory perspective, a recent study by the Banco de España analysed the risks and opportunities of AI in the financial system, highlighting the need for responsible governance, rigorous testing, and proactive management of risks such as algorithmic opacity, modelling biases, and cyber risks (Balsategui, Gorjón and Marqués, 2024). These contributions provide an essential conceptual framework for the development of RegTech, SupTech and ResTech solutions based on security, reliability and ethical criteria.

Accordingly, ample opportunities exist for new lines of research into the application of innovative technologies to market infrastructure solutions, as well as for progress in the political and technical discussions aimed at promoting greater coordination between institutions and entities at national and international levels. This convergence is essential for ensuring an effective, coordinated response to potential crisis situations affecting critical actors in the financial system.

3 RegTech and SupTech: the evolving ecosystem

Over the past decade, the financial regulatory environment has undergone an unprecedented transformation, driven by digitalisation and increasingly sophisticated markets. The need to manage complex information flows more effectively, improve operational efficiency, and respond quickly to emerging risks has given rise to specialised technology solutions for compliance and financial oversight. Two key trends have emerged in this context: RegTech and SupTech, representing key milestones in the modernisation of public and private sector financial architecture.

RegTech has become a fundamental tool in response to the heightened regulatory demands that followed the 2008 financial crisis. It aims to optimise compliance among regulated entities by using technologies that reduce costs, improve traceability, increase efficiency, and minimise human error. Its most relevant applications include Anti-Money Laundering/Countering the Financing of Terrorism, AML/CFT,[1] Know Your Customer, KYC,[2] automated regulatory reporting and risk analysis using AI[3] and machine learning. According to the RTA 2024 Industry Perspectives Report, 73% of respondents believe that generative artificial intelligence will significantly transform the RegTech sector within the next two years, particularly with regard to regulatory compliance, fraud detection, and sanctions management (The RegTech Association, 2024).

SupTech has emerged as a strategic component of financial authorities' efforts to strengthen their supervisory capacities.[4] By using technologies such as big data, machine learning, natural language processing and cloud computing, supervisors

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1 AML/CFT refers to the systems and procedures used to detect and prevent suspicious transactions, such as transfers of funds without economic justification, or the structuring of transactions to circumvent controls. These systems and procedures are designed to prevent money laundering and terrorist financing. One example would be algorithms that identify unusual patterns in bank account movements.

2 KYC (Know Your Customer) refers to the process by which a financial institution verifies the identity of its customers before entering into a business relationship. This process may include reviewing official documents, such as passports or proof of address, as well as using biometric technologies, such as facial recognition, and consulting databases to verify records. A common example is the digital identification of a customer when opening a bank account online, where a photograph of the identity document is requested alongside real-time verification via video or facial recognition.

3 Artificial intelligence and machine learning enable entities to detect complete patterns in large volumes of data, thereby facilitating the automation of regulatory tasks. For instance, a RegTech system can analyse millions of transactions in real time to detect unusual behaviour associated with money laundering, thereby reducing the need for manual reviews and improving the speed of risk detection.

4 ESMA (2023). *Strategy 2023-2028*. p. 30. "ESMA will continue to support NCAs' supervision – strengthening convergence in the use of digital technologies and SupTech tools, including the sharing of best practices and the conducting of joint projects".

can adopt new tools to visualise systemic interconnections, monitor markets in real time, and detect anomalous patterns of financial behaviour. This facilitates both the supervision of business conduct and prudential and macroprudential oversight. ESMA has documented several SupTech use cases, including automated reporting systems, market surveillance, and forward-looking risk analysis based on early indicators (ESMA, 2022). ESMA has also studied the potential impact of AI on EU securities markets, as well as its progressive integration into SupTech tools (ESMA, 2023).

Both RegTech and SupTech share a common technological foundation centred on process automation, big data analytics, and system interoperability. However, they differ in their orientation: RegTech is designed for implementation by regulated entities (banks, insurers, etc.), whereas SupTech is implemented by supervisory authorities, enabling them to anticipate and respond to risks more effectively.

The evolution of this digital ecosystem is driven by two institutional motivations: achieving operational efficiency in a context of limited resources, and improving the capacity to act in the face of the growing complexity and dynamism of the financial system. This logic has paved the way for a new generation of solutions targeting critical functions such as bank resolution and crisis management. Some experts are referring to this as 'resolution technology' (ResTech). This concept is a logical extension of SupTech, focusing not only on diagnosis and prevention, but also on efficiently executing resolution processes. This marks a new stage in the digital transformation of public financial governance.

Alongside the deployment of AI-based solutions within the RegTech and SupTech ecosystems, European authorities have begun to pay increasing attention to the risks associated with their use. The recently adopted EU Regulation on Artificial Intelligence introduces a risk-based approach that classifies AI systems according to their potential impact. It imposes specific transparency, human oversight, data governance, and fundamental rights protection obligations, particularly for high-risk uses such as credit assessment and automated financial monitoring. Similarly, the Banco de España has emphasised the importance of making progress in the responsible use of these technologies, while being aware of their transformative potential and the associated ethical dilemmas, security risks, privacy issues, algorithmic bias and lack of explainability of generative AI models. In its article published in the *Revista de Estabilidad Financiera* (No. 47, 2024) it stresses that the authorities should lead by example by applying these tools in controlled environments, developing robust governance frameworks, and promoting ethical and technical standards to ensure reliable, transparent, and safe deployment in the financial system.

4 ResTech: towards the digitalisation of resolution in a fast-paced financial context

ResTech refers to the digitalisation of resolution in a fast-paced financial environment. ResTech is an emerging concept referring to the use of advanced technologies to support resolution authorities in banking and market infrastructures, especially central counterparties (CCPs), at all stages of the crisis cycle, from ex-ante planning to the operational execution of resolution measures and the ex-post assessment of their effectiveness. Although not yet formally recognised in existing regulatory frameworks, nor fully integrated into the institutional strategies or organisational structures of resolution authorities, ResTech is gaining relevance as an area of technological innovation with autonomous potential, especially in light of recent developments in RegTech and SupTech.

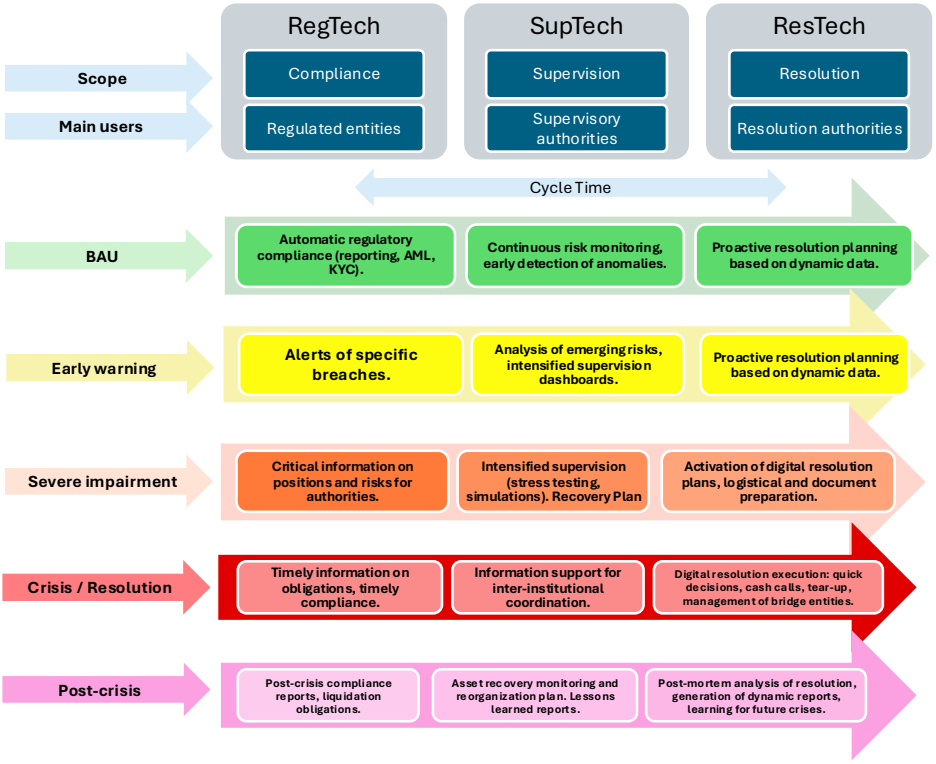
Unlike RegTech, which optimises regulatory compliance for supervised institutions, and SupTech, which enhances supervisory capacity, ResTech addresses an essential operational need by providing resolution authorities with the technical tools to act with agility, efficiency, knowledge and coordination in crisis situations involving complex decisions under high pressure and in cross-border environments. Additionally, ResTech can play a strategic role in the preventive phase,[5] facilitating the early identification of structural risks, assessment of interdependencies between entities or critical functions, and continuous improvement of resolution plans.

As Loiacono and Rulli (2022) highlight, ResTech signifies a shift from passive resolution planning to a dynamic, executable environment capable of adapting to evolving events during an actual crisis. In this way, ResTech increases the speed and accuracy of the institutional response and enhances the legitimacy and traceability of decisions taken in contexts that are highly sensitive to financial stability.

Although ResTech shares underlying technologies with SupTech, such as process automation, interactive visualisation, predictive analytics and artificial intelligence, it would be deployed at a different stage of an entity's degradation cycle, when preventive monitoring gives way to the adoption of resolution measures in the event of a situation of non-viability or serious risk to financial stability. Therefore, it should be understood as a distinct functional extension of SupTech, with its own technical, legal and organisational implications, aimed at facilitating the efficient, coordinated and documented execution of decisions in critical contexts.

5 Tools such as resolution simulators, resolvability dashboards, and automatic validation systems for the input and output conditions of resolution instruments are outstanding examples of this.

Focus and uses of RegTech, SupTech and ResTech FIGURE 1



Source: Author's own work.

4.1 A fast-paced financial environment: why ResTech is becoming strategic

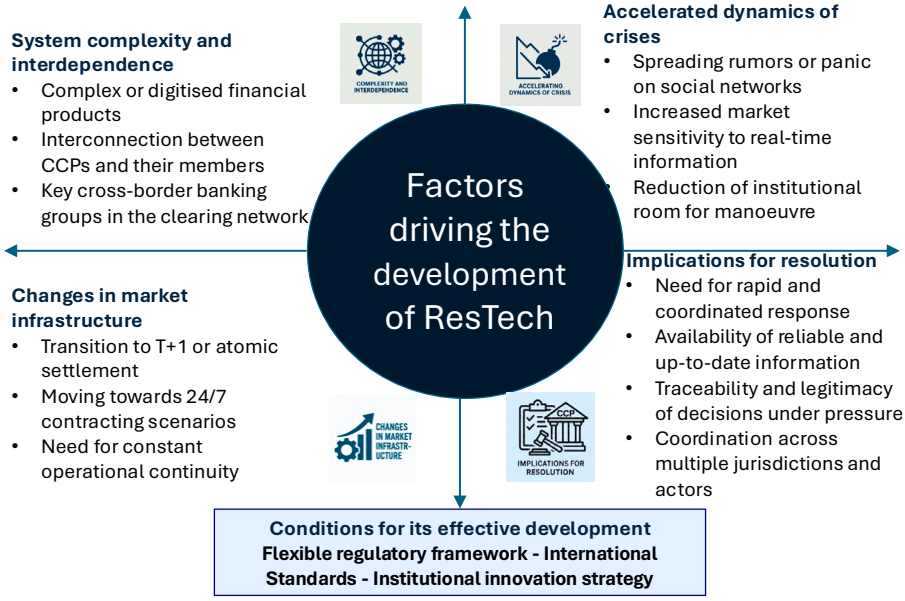
In a context of increasing financial complexity driven by the expansion of complex or digitised products and the increasingly systemic role of market infrastructures – particularly CCPs – as well as the deep operational and financial interdependencies they generate and the persistent vulnerability of certain systemically important banks, the development of ResTech could be a key strategic asset for resolution authorities.

This need is accentuated by the increased speed with which financial crises can be triggered and spread, driven by the use of digital technologies, the instantaneous dissemination of information through social media and the move towards accelerated settlement times (T+1 or even atomic settlement), in addition to the emerging trend towards 24/7 trading in the securities markets served by CCPs.[6]

6 It responds to the increasing digitalisation of the sector, the globalisation of financial markets, and the demand for constant availability from users and investors. This involves process automation, advanced technological infrastructure and, in some cases, the involvement of external suppliers to ensure uninterrupted operations. Examples include trading in crypto-asset markets, automated customer support and constant access to trading platforms.

In this environment, ResTech can contribute to strengthening institutional response capacity, especially if its development is accompanied by an adapted regulatory framework, international standards for interoperability and data governance, and a sustained technological innovation strategy.

Context and conditions justifying the move towards ResTech FIGURE 2



Source: Author's own work.

4.2 Enabling technologies and their applications in processes of preventive and enforceable resolution

The potential development of ResTech is supported by enabling technologies already present in the RegTech and SupTech ecosystems. These technologies are beginning to be explored in academic research and institutional design for their applicability to resolution processes, both in the early planning stages and in the implementation of measures during a crisis. These technologies do not act in isolation, but rather combine to create integrated solutions that can anticipate, plan, execute and document decisions in high-pressure, operationally complex environments.

In the foreseeable future, such technological solutions could enable us to:

– Integrate and process large volumes of relevant data through data lake[7] architectures.

7 A data lake is a data storage architecture that allows information from multiple sources to be centralised in its original format, whether structured (e.g. relational databases) or unstructured (e.g. emails, documents or system logs). Unlike traditional data warehouses, data lakes allow for more flexible ingestion and agile analysis of large volumes of data. This is particularly useful in crisis contexts, where a cross-cutting, up-to-date, dynamic view of the situation is required.

– Simulate complex resolution scenarios, incorporating different combinations of instruments (such as specific bank resolution tools, including bail-in or sale of the business or the bridge institution, as well as CCP-specific mechanisms such as cash calls, profit haircuts or the creation of a bridge CCP).

– Dynamically assess compliance with resolvability requirements.

– Model and calculate the potential costs of resolution through different methodologies and scenarios.

– Automate legal, operational and reporting workflows during the "resolution weekend".

– Deploy dashboards[8] that facilitate the monitoring of resolvability.

– Facilitate the preliminary loss assessment necessary for resolution.

– Coordinate decisions across multiple authorities, jurisdictions, and private sector actors through secure, traceable, collaborative environments.

During the **preventive phase**, these technologies can facilitate proactive preparedness based on the continuous updating of resolution plans, the identification of critical functions, the early detection of signs of impairment and the interactive assessment of institutions' resolvability. They can also facilitate scenario modelling and simulations of the impact of resolution measures on CCP members, banking groups, markets, and financial stability. During the **executive phase**, implementation would reduce critical timescales, facilitate the agile and rapid provision of relevant CCP information based on reliable, updated data, increase coordination between actors (both internal and cross-border), and ensure technical and documentary traceability of decisions and communications.

However, these technologies should be implemented with caution in controlled environments and accompanied by appropriate governance, technical validation and legal oversight frameworks, particularly when dealing with artificial intelligence or advanced automation components.

Some of the key technologies being explored, or partially adopted in pilot initiatives or institutional applications linked to financial resolution, are described below, along with examples of their potential applications in the preventive and executive phases.

8 Dashboards enable resolution authorities to view key indicators related to an institution's resolvability in an integrated manner, such as compliance with MREL requirements, liquidity status, exposure to critical counterparties, and the operability of critical functions. For instance, they can display real-time alerts regarding gaps in loss absorption resources or incidents in payment or custody systems.

Enabling technologies and their application in the resolution processes TABLE 1

Enabling technology	Main applications	Phase of the resolution process
Data lakes and distributed architectures	Integration of financial and operational data for cross-cutting analysis	Preventive
Generative Artificial Intelligence (GenAI)	Prediction of impairment, assessing resolvability and classifying critical functions. Prioritisation of actions and impact analysis	Preventive and executive
Resolution simulators	Modelling and testing resolution strategies under multiple scenarios	Preventive and executive
Robotics	Structured execution of administrative tasks and generation of orders and communications	Executive
Distributed ledger technologies (DLT) and blockchain	Monitoring and traceability of decisions, coordination and synchronisation between authorities, and implementation of instruments	Executive
Big data and advanced analytics	Processing of structured and unstructured data to generate alerts, risk patterns and interdependency maps	Preventive and executive
Interactive dashboards and visualisation	Monitoring the operational status of a CCP, ISF or bank, as well as their related parties through key indicators	Preventive and executive
Collaborative environments and cloud computing technologies	Deploying ResTech solutions that are scalable, secure, and accessible from multiple jurisdictions. Assignment of tasks and coordinated execution of plans	Preventive and executive
Quantum computing and quantum-inspired computing	It could transform the simulation of extreme scenarios, optimise complex resolution strategies in real time and improve early detection of systemic risks	Preventive and executive

Source: Authors' own work, based on the FSB glossary (2020).

These solutions must be able to interact and share information with other authorities – both nationally and internationally – in a seamless, fast and efficient manner that respects common communication, interoperability and data protection standards. This capacity for institutional connection is particularly critical in cross-border resolution contexts, where coordination between jurisdictions can mean the difference between success and failure of an intervention.

Conversely, adapting these technologies to specific sectors is essential for their effectiveness. In the case of CCPs, for instance, ResTech solutions must be capable of processing large volumes of transactions in real time, managing complex contractual relationships, and operating within environments with multiple, simultaneous legal frameworks. Only a solution that considers this specific operational complexity can be of real use in high-pressure contexts, where time, accuracy and traceability are critical factors.

In the not-too-distant future, one area of enormous potential for ResTech will be quantum computing.[9] As the AMETIC report (2022) highlights, quantum

9 Quantum computing is a computing model based on the principles of quantum mechanics, which uses qubits (quantum bits) instead of classical bits to process information. Unlike classical bits, which can only have a value of 0 or 1, qubits can represent multiple states simultaneously due to the phenomenon of superposition. This feature enables quantum computers to solve certain computational, simulation and

computing promises to deliver processing capabilities that are exponentially faster than those available today. This will make it possible to solve simulation, optimisation and data analysis problems that are intractable for classical computing. In financial resolution, quantum computing could transform our ability to simulate systemic crises, improve predictive models of entity impairment, and optimise the allocation of critical resources in real time during resolution situations. Although its practical implementation still faces technical and scalability challenges, its progressive development positions it as a strategic technology for the future of financial resolution.

Meanwhile, quantum-inspired computing is emerging as a new algorithmic paradigm that applies principles and techniques derived from quantum mechanics to solve complex problems without using an actual quantum computer. This approach is finding applications in areas such as simulation, finance and risk management (MTDFP, 2025).

Taken together, emerging technologies such as artificial intelligence and big data, as well as more revolutionary technologies such as quantum computing, form an innovation ecosystem that promises to radically transform the capabilities of analysis, simulation and response to systemic crises when applied to the field of financial resolution.

4.3 The potential of generative artificial intelligence in the development of ResTech solutions and its application to simulation exercises (SimEx)

Although it was mentioned briefly in the previous section, generative AI deserves specific attention due to its growing prominence in the regulatory field, particularly with regard to its potential to disrupt the development of technological solutions for resolving financial crises (ResTech). Based on large language models (LLMs), GenAI enables the analysis of large volumes of data and the generation of textual content. It can also automate complex tasks and simulate behaviour in real time. These are highly valuable capabilities in crisis situations.

In the context of ResTech, GenAI can play a transformative role in the planning and execution of resolutions. Its applications include automatically generating key documents (e.g. resolution agreements, stakeholder notifications or institutional communication templates), synthesising applicable legal and regulatory frameworks for each situation and intelligently tracing decisions and actions to facilitate compliance with the principles of auditability and accountability.

One of the most promising areas of GenAI integration is simulation exercises (SimEx), which are recognised by European authorities as a key tool for assessing operational readiness and responsiveness in crisis scenarios. The European

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optimisation problems exponentially faster than classical computers. Although quantum computing is still in the developmental stage, it has strategic potential in areas such as cybersecurity, advanced artificial intelligence, and the simulation of complex financial models.

Banking Authority's (EBA) guidelines on resolvability testing (EBA/GL/2023/05) explicitly instruct resolution authorities to design multi-year testing programmes that include simulation exercises. These programmes are intended to verify not only regulatory compliance, but also the ability to effectively execute resolution strategies in a coordinated manner.

In line with recent European technical literature on the organisation of such exercises, different types of simulations have been identified, ranging from desktop exercises to end-to-end simulations, whose complexity and realism can be significantly enhanced through the use of emerging technologies. In this context, GenAI can provide a differential value:

- It can dynamically create 'injects', i.e. messages or stimuli introduced during exercises to simulate new or unforeseen developments, such as announcements by other authorities, market reactions, or adverse events. These injects force participants to make decisions and adapt to the evolving scenario. GenAI would enable these injects to be generated adaptively according to the participants' responses, thus enriching the experience and learning.

- Automated generation of simulated responses from third parties (other authorities, financial institutions, media, etc.).

- Support to facilitators and observers through summaries and alerts generated in real time.

- Automated synthesis of post-exercise results, including analysis of institutional performance.

- Multi-jurisdictional scenarios can be adapted in a rapid and coherent manner.

Furthermore, integrating GenAI into SimEx could significantly reduce the logistical preparation required, enable a higher frequency of these exercises, and facilitate cross-border collaboration through standardised, adaptable scenarios. This is in line with the principles of proportionality, flexibility and continuous improvement set out in the aforementioned EBA guidelines.

However, as Balsategui, Gorjón and Marqués (2024) caution, the adoption of these technologies necessitates a robust governance framework to ensure human oversight, algorithmic transparency, protection of sensitive data, and adherence to the core principles of the resolution process.

In short, GenAI offers a significant opportunity to improve the efficiency, agility, and realism of simulation exercises and resolution processes. However, its implementation must be carried out prudently, with full respect for institutional quality standards and legal certainty.

4.4 Current status of the use of ResTech by resolution authorities

Although the term "ResTech" has not yet been formally defined in international regulatory frameworks, initiatives incorporating technological tools in different phases of the resolution process are becoming increasingly visible, particularly in the banking sector. However, uptake remains limited and uneven, with significant differences between jurisdictions in terms of technical capacity, resource availability, and strategic priorities.

The FSB's Resolution Report 2024 emphasises the increasing importance of digital capabilities as a vital component of effective, coordinated and resilient resolution. While the report does not explicitly use the term 'ResTech', it identifies several areas in which digitalisation could have a transformative impact.

Firstly, it stresses the urgent need for authorities to have integrated, secure, real-time information systems that are kept up to date. In recent years, one of the main constraints has been the difficulty of accessing reliable data in a timely manner, which compromises the ability to react in critical situations.

Secondly, the report emphasises the usefulness of automated tools in standardising and generating normative documentation, reducing operational errors, and facilitating coordination between the various institutions involved in crisis management.

It also promotes the use of simulators and collaborative digital environments to test resolution plans, integrate real-time data, distribute tasks and test the robustness of operational frameworks. The FSB also identifies technological interoperability – the ability to share information across jurisdictions under common security, traceability and confidentiality standards – as a key requirement for effective cross-border resolution (FSB, 2021).

While these recommendations primarily concern the banking sector, many are also applicable to other critical financial infrastructures, such as CCPs, where considerable progress in digitising the resolution framework is still possible.

In Spain, although no formal strategy has yet been articulated, the Banco de España and the FROB (Executive Resolution Authority) have started to integrate technological solutions into their functions.

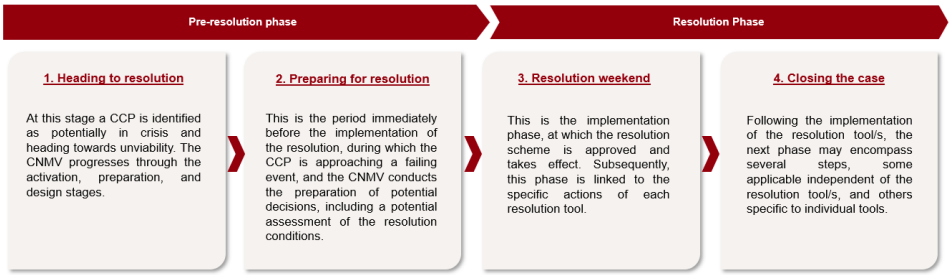
According to its 2024 Supervisory Report (Banco de España, 2025), the Banco de España has strengthened its analytical and technological capabilities by developing internal tools to improve data processing, scenario assessment and risk management. These developments respond to the need for infrastructures that are more agile, resilient and forward-looking.

The FROB has accelerated its digitalisation process by participating in internal and SRB-organised crisis simulations, including dry runs, as detailed in its 2022 Activities Report (FROB, 2023) and 2023 Activities Report (FROB, 2024). These experiences have made it possible to test procedures and information flows in simulated environments and collaborative digital spaces, bringing resolution operations closer to a more dynamic and technologically assisted logic.

In the area of non-banks, the CNMV has also promoted technological developments in its role as resolution authority for ISFs and CCPs. This includes developing a dashboard to monitor the resolvability and resolution plans of ISFs, and partially automating their preparation.

Regarding CCPs, the CNMV intends to conduct a mock resolution exercise in mid-2025 and has organised information sessions to enhance understanding of and preparedness for the applicable resolution scheme. Additionally, the CNMV is developing an operational resolution handbook for CCPs, the Crisis Management Handbook (CMH), which will cover all phases of the process, from resolution preparation and activation to crisis exit. The handbook will define the relevant procedures, roles and teams, timelines, decision-making templates, orders and communications, and the applicable governance processes and regulatory frameworks. Its deployment will be supported by an artificial intelligence-based technological tool in a cloud environment, which will facilitate its practical application, improve operational traceability, and enable adaptation to different crisis scenarios.

Phases envisaged in the CNMV's CMH on the resolution of CCPs FIGURE 3



Source: Authors' own work.

These developments, although still fragmentary, point towards a progressive integration of ResTech capabilities into the Spanish resolution ecosystem. Consolidating these capabilities under a common strategic approach that connects technological innovation with regulatory governance could be key to strengthening the effectiveness, coordination, and legitimacy of the resolution process as a whole.

5 Key elements for integrating ResTech into the resolution of CCPs

While the application of innovative technologies in CCP resolution offers significant opportunities, it also poses specific technical, legal, and operational challenges. As critical infrastructures of the financial system – highly interconnected with markets, participants and jurisdictions – CCPs require particularly rigorous, transparent and coordinated resolution planning and execution.

This section identifies the key elements for the effective integration of ResTech in this area. It analyses the roles these tools can play, from the planning of resolution measures to their implementation and monitoring, as well as the necessary enabling conditions, such as technical interoperability, data governance, cyber resilience, human oversight and compliance with national and European legal frameworks.

The objective is to demonstrate how a well-designed digital architecture can strengthen the institutional capacity to anticipate, manage, and overcome crises affecting key entities in the financial ecosystem.

5.1 Application of ResTech to the planning and implementation of the resolution

The resolution of a CCP requires a precise, technically sound and legally robust intervention. In this context, ResTech solutions can provide greater agility, coordination and traceability in both the preparatory phase and the implementation of resolution measures. The main functionalities by phase are described below:

i) Preventive phase: planning, simulation and monitoring

Effective preparedness begins with the development of a comprehensive, up-to-date resolution plan identifying critical CCP functions, associated risks, and failure scenarios. ResTech tools can add value in several ways:

- Dynamic data integration and visualisation, through real-time dashboards connected to internal and external information sources.
- Automation of resolvability analysis, incorporating materiality, interdependencies and execution conditions criteria.
- Generation of early warnings based on structural or operational risk indicators.

– They can simulate stress scenarios, such as the simultaneous bankruptcy of several clearing members, payment disruptions or technological failures, to assess the robustness of the scheme.

– Losses and potential resolution costs can be calculated through models in different scenarios. Identification of possible gaps in financial resources available for resolution.

– Preliminary public interest analyses are conducted under different scenarios, and CCP data is accessed in real time for interim assessments and impact analysis of different resolution tools.

– Interactive digital drills are used to rehearse responses, train teams, and improve decision-making and communication protocols.

These functionalities improve the technical quality of the plan and strengthen the culture of preparedness, institutional response capacity, and multilateral coordination, particularly in cross-border situations.

ii) Executive phase: activation, implementation and monitoring

In the event of the resolution scheme being activated, ResTech could be instrumental in ensuring the measures set out in the plan are implemented rapidly, in a coordinated manner and securely. Potential contributions include:

– Partial automation of operational decisions, subject to pre-defined thresholds and human control mechanisms.

– Analysis of public interest in resolution.

– Provisional pre-assessment by the resolution authority and calculation of resolution costs. Comparison with the insolvency liquidation scenario.

– Assessment of the impact on members, the market and financial stability of the envisaged resolution measures.

– Intelligent assignment of tasks and workflows with traceable responsibilities and timescales.

– Critical measures, such as transfer blocks, margin calls or liquidity calls, are activated immediately.

– Real-time monitoring of resolution status through inter-institutional collaborative environments.

– Sophisticated mechanisms to maintain confidentiality and traceability of the information used to make resolution decisions.

– Automatic reporting to national and international authorities and affected stakeholders.

These functionalities are particularly relevant in scenarios requiring accelerated intervention, such as when resolutions need to be executed over a weekend to avoid contagion effects and adverse impacts on the markets served by the CCP. The ReSpace[10] platform illustrates how collaborative digital environments can facilitate an agile, interconnected and data-driven response by connecting authorities directly to relevant information systems.

The following table lists the tools foreseen in the CCP resolution frameworks and discusses how ResTech technologies can be applied in both the planning and implementation phases. For each tool, the operational benefits of using emerging technologies (such as artificial intelligence, distributed ledger technology (DLT), application programming interfaces (APIs) and legal automation) are detailed, as well as the associated systemic risks. This allows for the identification of priorities and conditions for their effective adoption.

Application of ResTech in CCP resolution tools TABLE 2

Resolution tool	Definition	Planning (ResTech)	Execution (ResTech)	Systemic risk
WDCI (write-down and conversion of instruments)	Write-down or conversion of equity or debt instruments to absorb losses and recapitalise the CCP.	Resolution simulators, recapitalisation algorithms and natural language processing (NLP) applied to contracts: estimating loss absorption requirements, impact simulation and validation of legal implications.	Legal automation through robotic process automation (RPA), generation of digital instruments and use of distributed ledger technologies (DLT): automated issuance of instruments, logging of resolution events and synchronised communication between authorities.	Low, if well executed; depends on the legal framework and market acceptance.
Cash calls	Extraordinary cash requirements from members to cover unabsorbed losses.	Predictive analytics, interactive liquidity dashboards and member scoring through advanced analytics and ML: assessing responsiveness and early identification of potential defaults.	Systems integration via APIs, automatic notifications and real-time validation via RPA: triggering of requirements and verification of compliance by members.	Risk of contagion, if members do not provide liquidity; pro-cyclical effect.
VMGH (variation margin gains haircutting)	Proportional reduction of outstanding profits to cover deficits.	Haircut simulators, impact visualisation and incentive analysis using advanced analytics and ML: calculation of expected effects per member or product.	Automation of calculations via RPA and registration via DLT: application of the haircut, notification of members and traceability of impacts.	May discourage participation; creates stress in volatile markets.

10 ReSpace is a financial crisis management and simulation platform developed for resolution environments. It allows authorities to share critical information in real time, coordinate strategic decisions, and execute resolution plans synchronously, thereby minimising the risk of misalignment and maximising the traceability of actions

Application of ResTech in CCP resolution tools (*continuation*) TABLE 2

Resolution tool	Definition	Planning (ResTech)	Execution (ResTech)	Systemic risk
Tear-up: partial or total cancellation of contracts	Forced cancellation of offsetting positions to stop losses.	Selection of offsetting positions using exposure simulators and ML: identification of combinations with the lowest residual impact for possible cancellation.	Cancellation automation via RPA and real-time monitoring of exposures through interactive dashboards: technical execution of the cancellation and adjustment of associated collateral.	Medium, due to direct involvement of members and legal complexity.
Bridge CCP	Temporary transfer of operations to a bridge institution.	Mapping interdependencies and analysing critical functions using big data and ML: defining the essential operational perimeter and simulation of transfer scenarios.	Transfer of contracts with traceability via DLT and automated contract validation via NLP processing: ensuring business continuity and legal certainty in the transition.	Low, if predefined; complex without prior agreements.
Sale of business	Total or partial transfer to a third party that continues the operation.	Identification of potential buyers through matching algorithms, synergy analysis and segmentation with ML: preparation of the offer and simulation of the impact on operational continuity.	Enabling virtual data rooms and contract automation via robotic process automation (RPA): facilitating due diligence, negotiation and closing of the transaction.	Low, if there is a viable buyer; risk if the process is protracted.
Orderly liquidation	Controlled closure with distribution of assets to creditors according to legal hierarchy.	Automated legal classification via NLP processing and coded rules; use of distribution simulators with advanced analytics: estimation of expected recoveries and duration of the settlement process.	Payment automation via RPA and traceability via DLT; coordination of mass communications via cloud computing technologies: execution of payments according to legal precedence.	High, due to loss of value and possible contagion if it is not properly managed.

Source: Authors' own work and Gómez-Yubero (2022).

5.2 Application of ResTech in international cooperation and automation of critical processes

For CCPs with cross-border activity, close and effective cooperation between resolution authorities in different jurisdictions is an essential element to ensure business continuity and market integrity. The fragmentation of competencies, regulatory frameworks and information flows can hinder an orderly resolution in the absence of technological mechanisms that facilitate real-time coordination.

In this context, ResTech solutions can act as facilitating infrastructure, providing tools designed specifically to support joint decision-making and synchronised execution of resolution measures. These include:

- The use of distributed ledger technologies (DLTs), which allow critical information to be shared securely, transparently and traceably between multiple authorities, thereby ensuring data integrity and version synchronisation.

- The integration of application programming interfaces (APIs), which automate critical processes such as executing margin calls, activating tear-up mechanisms and transferring counterparties to bridging entities.

- Collaborative digital spaces can be implemented to manage shared workflows, assign tasks, perform electronic validations and monitor deadlines in line with established operational procedures.

Regulation (EU) 2021/23 (also known as CCPRRR) on the CCP recovery and resolution framework stipulates that decisions on the resolution of a CCP with an international presence must be made jointly and in coordination with all the relevant authorities. To comply with this principle, ResTech platforms can incorporate collaborative, governance-oriented functions such as:

- Version control of resolution documents.

- Electronic signature and multilateral validation of decisions.

- Institutional traceability of process milestones and communications.

These functions can be implemented through digital repositories, secure messaging systems, document collaboration platforms, and remote monitoring tools, which not only improve the efficiency of the process, but also its transparency and auditability. Ultimately, well-designed ResTech architecture can reduce institutional friction in high-pressure situations and reinforce the collective capacity to manage crises coherently, promptly and legally across borders.

Scenario: coordinated activation of the resolution plan of a cross-border CCP EXHIBIT 1

Scenario: Imagine a central counterparty (CCP) based in one EU Member State that serves markets in three European jurisdictions through interoperability arrangements. Its clearing members are spread across several countries. During an episode of high volatility in energy markets, two key CCP members default on their hedging obligations, generating substantial losses that deplete the CCP's default fund and trigger the resolution threshold.

The lead resolution authority then convenes the resolution college as set out in Regulation (EU) 2021/23. Thanks to a pre-implemented ResTech platform shared between the authorities, the process is agile and synchronised:

– A shared digital workspace is activated to host the resolution plan, operational documents, decision flows and agreed timelines.

– Through distributed ledger technologies (DLTs), all authorities share critical CCP financial information in real time, including exposure data by member, collateral availability, and margin requirement fulfilment status.

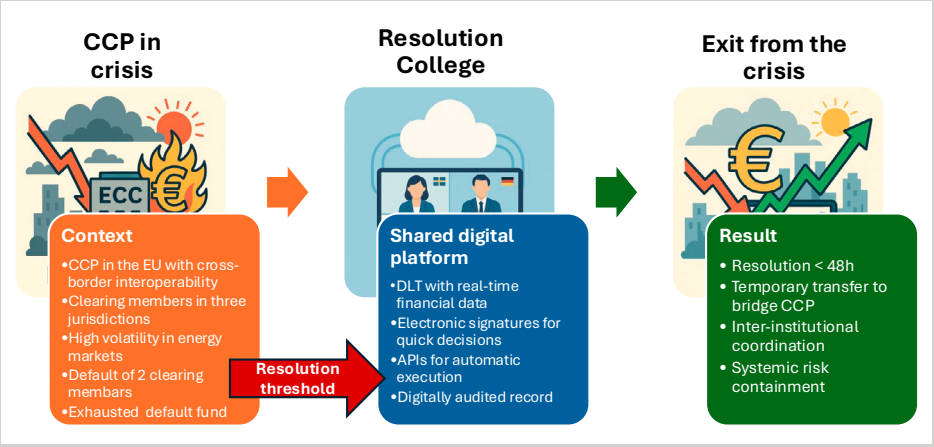
– Using electronic signatures integrated into the platform, the heads of each authority can approve the planned measures, including a partial tear-up to contain losses and a temporary transfer of certain critical functions to a pre-designed bridge entity, in a matter of minutes (dynamic workflow).

– Application programming interfaces (APIs) integrated with the CCP's systems enable the automatic execution of cash calls and provide real-time updates on each member's status.

– All activity is recorded in a digitally audited log, enabling the process to be reconstructed and justifying each decision, while ensuring the traceability of decisions and communications.

Thanks to this ResTech infrastructure, resolution can be executed in less than 48 hours without operational disruption, with full inter-agency coordination, and adverse market reactions can be avoided. This case study shows that advanced technology improves process efficiency, reduces systemic risk, and strengthens the legitimacy of regulatory action in the eyes of market participants.

Example of a ResTech resolution of a CCP in a crisis context FIGURE 4



Source: Authors' own work.

5.3 Application of ResTech in the ordinary settlement of non-critical functions

In the context of a CCP resolution, not all activities need to be preserved. Those that are not critical to financial stability, the continuity of essential services, or market integrity can be excluded from the resolution perimeter. They can then be dealt with through normal liquidation mechanisms, in accordance with applicable insolvency procedures.

This functional separation, as set out in Regulation (EU) 2021/23, enables the relevant authorities to focus their efforts on ensuring the continuity of critical services while delegating the management of non-strategic assets and liabilities to more traditional judicial or administrative procedures.

In these cases, ResTech can play a significant role in improving the efficiency, traceability and transparency of settlement processes. Applications include:

– Digital organisation of documentation, which facilitates structured access to contracts, accounting records and legal documentation.

– Automation of administrative tasks and communications, such as generating creditor notifications, drawing up credit lists and scheduling payments in order of priority.

– Centralisation of operational information allows it to be monitored by the competent authority or the insolvency practitioner.

– Digital dashboards that reflect the status of the process, completed stages, pending milestones and estimated times in real time.

This approach enables non-critical functions to be closed in an orderly, efficient and transparent manner, minimising the cost and duration of the process while ensuring consistency in operations and communications with the rest of the resolution strategy. Furthermore, the automation and digitalisation of the process facilitates coordination with other involved parties (including judges, creditors and liquidators), contributing to a liquidation process that aligns with the principles of integrity, accountability, and the protection of the financial system's interests.

6 Operational and strategic risks arising from the digitalisation of CCP resolution

Using ResTech technologies to resolve CCPs can significantly improve the preparation, implementation and monitoring of resolution measures. However, it also introduces operational, technological and strategic risks that need to be anticipated and managed from an early stage of design and implementation.

Experience in the RegTech and SupTech fields shows that, alongside advances in efficiency, traceability and agility, digitalisation introduces new vulnerabilities requiring a rigorous institutional approach. These risks affect not only resolution authorities, but also the entire institutional setup involved in resolution processes, including the CCPs themselves, prudential supervisors, external advisors (strategic, legal and valuation experts, etc.) and other parties, all of whom must adapt their technical, organisational and governance capabilities to operate in an increasingly automated and demanding environment.

Therefore, the management of these risks must be addressed in a coordinated, proactive and shared manner as part of a comprehensive digital resilience architecture.

i) Operational and technological risks

Intensive use of technologies such as APIs, cloud services, DLT and specialised technology providers increases exposure to cyber-attacks, operational failures and systemic errors. If not properly managed, outsourcing critical functions can lead to excessive dependency on a limited number of third parties, with significant implications for business continuity in disruptive scenarios.

To mitigate these risks, it is imperative to develop robust cyber resilience frameworks, including:

– Advanced and multi-factor authentication.

– Logical segmentation of networks and compartmentalisation of functions.

– Encryption of sensitive data and access control.

– Technical redundancy and service continuity mechanisms.

– Regular stress tests and contingency plans.

The use of GenAI also presents significant risks:

– Inherent biases in training data that can perpetuate discrimination.

– Hallucinations and errors in generative models that can affect critical decision-making.

– Data privacy and cybersecurity vulnerabilities.

Therefore, it is essential to clearly define legal and contractual responsibilities for both technical failures and incorrect automated decisions, ensuring adequate human supervision throughout the process.

ii) Algorithmic opacity and strategic risks

Using algorithms in predictive models or for automated decision-making can lead to results that, if not well documented and validated, are difficult to interpret or justify – especially under pressure, as during a resolution process. This algorithmic opacity can undermine the legitimacy of institutional decisions.

In the case of CCPs, while the risk of deliberate manipulation is lower than in other environments, some participants may still adjust their behaviour strategically if they detect patterns in margin management, loss allocation or action triggers. To mitigate this risk:

– Models need to evolve and be updated continuously.

– A balance must be maintained between operational transparency and strategic confidentiality.

– Active human supervision that combines technical, regulatory and institutional governance criteria is essential.

iii) Data quality and governance

Digitising resolution processes through ResTech technologies leads to increased reliance on automated systems for analysis, decision-making, and executing critical actions. While this transformation offers clear advantages in terms of speed, efficiency and responsiveness, it also introduces the risk of erroneous or inapplicable decisions being made based on inadequate, incomplete or poorly managed data.

In environments where resolutions must be executed quickly under pressure, inconsistencies in data can lead to miscalculations of financial needs, inappropriate tool activation or breaches of regulatory limits. Furthermore, automation amplifies the effects of these mistakes: poor input generates poor output and can be massively and immediately escalated.

Therefore, ensuring the quality, availability, traceability and governance of data is not only a technical requirement, but also a structural factor in the viability of digitally enabled resolutions.

In the specific case of CCPs, this implies:

– Having up-to-date financial, contractual and operational data in real time.

– Ensuring full traceability of the data used in each decision.

– Implementing quality controls, cross-validation mechanisms and clear data governance, involving functional and technical managers.

Before applying advanced techniques such as artificial intelligence or automated simulations, it must be ensured that the data is reliable, consistent, and legally usable within the applicable legal framework. Without this foundation, ResTech can create a false sense of precision and control, thereby compromising the very stability and efficiency objectives it is intended to safeguard.

iv) Ethical, social and privacy risks

Technological progress is not without social and ethical risks. The AI Spain Report (Arcila Calderón et al., 2023) reveals that people have positive expectations of AI, but are also concerned about its ethical risks. The report warns of the need to regulate the impacts of AI, in order to avoid bias, threats to privacy and social imbalances.

According to the *Spain Quantum Industry Report* (AMETIC, 2022), revolutionary technologies such as quantum computing will have a highly transformative effect on the financial sector and introduce additional disruptions in terms of both ethics and cybersecurity and critical information processing. For a ResTech ecosystem, which depends on data integrity and confidentiality, these developments present both opportunities and challenges.

Privacy risks in the digital economy are also growing and becoming more complex. The Bains & Gaidosch report (2025) discusses how privacy technologies[11] (such as homomorphic encryption, federated learning, zero-knowledge proofing, differential privacy or secure multiparty computation) can strengthen trust in the digital economy by protecting personal data without sacrificing the use of information for financial innovation. The report stresses that a combination of data protection regulation, international collaboration, and technical supervision is essential for financial supervisors to manage privacy and cybersecurity risks. Furthermore, it points out that, although these technologies offer opportunities, they do not negate the need for robust regulatory frameworks and cyber security infrastructure.

11 Privacy-enhancing technologies (PETs) make it possible to use data without exposing it completely, combining innovation and protection of fundamental rights, which is crucial in the digital economy, in the financial sector and, of course, in the development of ResTech technologies.

v) Institutional capacities and support structures

The digitalisation of the resolution is not only a technological challenge; it is, above all, an institutional challenge. Effective adoption of ResTech solutions requires more than just the incorporation of new digital tools. It also requires a review of internal capabilities, a reorganisation of functions, and the development of an organisational culture ready to operate with advanced technologies in high-pressure scenarios.

From this perspective, the strategic risk lies less in the lack of technology than in the inadequacy of human and organisational structures to absorb it effectively. A lack of adequate technical profiles, rigid internal processes, or a lack of training in the use of complex systems can lead to ill-informed decisions, resistance to change, and critical dependence on third parties.

Therefore, the success of digital transformation in resolution authorities is closely linked to the availability of multidisciplinary teams that can combine technical expertise, regulatory knowledge, and an understanding of financial markets.

This institutional transformation includes:

– The development of teams with cross-cutting competencies in resolution, data science, cybersecurity, technology and critical infrastructure operation.

– Continuous staff training and the attraction of specialised technical profiles.

– Reviewing and adapting internal processes to ensure gradual, secure and supervised technological innovation.

According to Aldasoro, Gambacorta and Rees (2025), integrating artificial intelligence into central banks poses considerable governance, ethical and talent management challenges, which can also be extrapolated to resolution authorities. In their study, they emphasise the importance of adaptive institutional strategies that focus on ongoing training, attracting experts in new technologies, and fostering an organisational culture that balances regulatory rigour with innovation.

To mitigate operational risks arising from the use of emerging technologies, it is essential to promote safe learning and testing environments. Tools such as regulatory sandboxes, collaborative pilots and progressive testing programmes enable:

– Early assessment of the capabilities, limitations and biases of technological solutions.

– The building of institutional and operational confidence in their use.

– A reduction in the likelihood of critical failures when these tools are deployed in real crisis environments.

vi) Risk of asymmetric learning and technological capability gaps

The accelerating pace of technological development in the private financial sector poses a structural challenge for the authorities responsible for CCP resolution. One less visible but highly relevant strategic risk in this context is the *asymmetric learning risk*. This refers to the knowledge and experience gap that arises when private institutions adopt and master digital tools more quickly and thoroughly than supervisors or resolution authorities.

This phenomenon has been described in academic literature on public–private partnerships, where differences in organisational capacities and incentive structures generate persistent imbalances (Zheng and Caldwell, 2008). In the financial sphere, the FSB (2017) has warned that private actors' early adoption of artificial intelligence and big data may overwhelm supervisors' ability to understand, monitor, and respond effectively to the associated risks.

In the specific area of resolution, this asymmetry results in increasing operational dependence on third parties – such as technology providers, external consultants, and even CCPs themselves – to comprehend and implement digital solutions in crisis scenarios. If authorities lack equivalent internal capabilities to audit, replicate or validate automated decisions, their technical autonomy and decision-making legitimacy will be weakened.

To mitigate this risk, institutional strategies are required to:

- Reduce the technology adoption gap through sustained public investment in digital skills.

- Promote specialised staff training in data science, programming, algorithmic evaluation and cybersecurity.

- Promote institutional learning environments such as innovation labs, sandboxes and cross-regulatory collaborations.

- Establish ethical and methodological frameworks that allow for the transparent, auditable and safe use of technological tools applied to resolution.

This risk cannot be addressed exclusively through a reactive approach. A proactive strategy is needed to enable the authorities to maintain a dynamic learning curve and build institutional resilience in the face of constantly evolving technology. Otherwise, the digitalisation of the resolution risks deepening the public sector's reliance on tools that it does not fully control.

7 Recommendations for future lines of action by authorities in relation to ResTech applied to CCPs

Given the transformative potential of ResTech and the challenges posed by its adoption, it is important to identify strategic lines of action to facilitate its progressive development and effective integration into CCP resolution frameworks. The following recommendations are addressed to resolution authorities with the aim of promoting a joint, secure, and results-oriented approach to using innovative technologies for crisis management.

i) Promote a common definition and its inclusion in regulatory policy frameworks

One of the first steps should be to establish a shared definition of ResTech in international and European forums such as the FSB and ESMA, as well as with relevant authorities in the field of bank resolution such as the SRB and EBA. Have a clear conceptual basis that aligns national initiatives and promotes regulatory convergence.

ResTech should also be integrated into the European Union's legislative and strategic frameworks, following the example of SupTech, which is already recognised by institutions such as the FSB, IOSCO, ESMA, the ECB and the EBA. This would reinforce its institutional legitimacy and facilitate the channelling of resources and efforts at the European level.

ii) Foster technological cooperation and joint development of solutions

Given the technical complexity and high costs associated with developing many ResTech tools, it would be timely to explore integrating them into European technology mutualisation initiatives. In this regard, coordinated action through ESMA could be considered to promote their financing and development within the framework of the EU Technical Support Instruments, which are managed by the European Commission's Reform and Investment Task Force (European Commission, n.d.).

It is also proposed that the SupTech expert network, currently coordinated by ESMA, should incorporate a specific ResTech work stream with the aim of:

- Sharing best practices among resolution authorities.
- Developing reusable and scalable joint solutions.
- Exploiting existing technological synergies in the supervisory field.

iii) Design and test pilot platforms in controlled environments

To move from conceptual design to practical application, it would be useful to develop pilot projects that simulate real resolution situations, including aspects such as:

– Automated execution of resolution measures.

– Institutional traceability of decisions.

– Operational coordination between authorities in real time.

These pilots could be carried out in sandboxes in collaboration with real or fictitious CCPs, with permanent technical and legal supervision. This would enable the performance of the tools to be reliably assessed prior to their operational deployment.

iv) Strengthen institutional capacities and evaluation frameworks

The integration of ResTech also requires a strengthening of the international capacities of resolution authorities, through:

– Sustained investment in technological infrastructure.

– Formation of multidisciplinary teams with legal, technological and operational expertise.

– Review of internal processes to incorporate new tools in a secure and legally compliant manner.

Additionally, specific evaluation indicators should be developed to measure compliance with the principles of safety, effectiveness, transparency, and alignment with resolution objectives. These indicators could be integrated into the regular resolution plan review cycles and also serve to inform other stakeholders in the financial system.

v) Consolidate ResTech as a useful and legitimate tool in crisis management

Taken together, these measures can help to consolidate ResTech as a useful, secure, and legitimate tool for resolution authorities. Adopting it should not be seen as an end in itself, but as a means to improve institutional preparedness, operational effectiveness and responsiveness to complex crisis situations, particularly with regard to critical infrastructures, such as CCPs.

vi) Establish a regular certification system for ResTech tools

Given the critical role that ResTech solutions can play in resolving CCPs, it is essential that the relevant authorities promote a certification system for these tools, with regular recertification. This certification should verify aspects such as technical soundness, algorithmic transparency, data traceability, interoperability with other infrastructures, and compliance with applicable regulatory requirements. The regular recertification process would also enable the assessment of the impact of updates, changes in regulatory frameworks, and new emerging risks, thus ensuring the reliable and safe use of these tools in highly sensitive operational contexts. A robust certification framework could also help to build trust between stakeholders and reduce reliance on *ad hoc* validations in emergency situations.

vii) Strengthen collaboration with academia and the research community

To foster the development of ResTech, it is important for resolution authorities to establish stable relations with academia. Working with universities, research centres, and technology experts provides access to innovative ideas and emerging technologies, such as artificial intelligence and network analysis, and enables the testing of new tools in controlled environments. It also facilitates the organisation of seminars and spaces for exchange that enhance the joint development of solutions. This type of collaboration has already been successful in SupTech and could be pivotal in ensuring the safe and effective adoption of ResTech for the resolution of CCPs.

8 Conclusions

ResTech offers resolution authorities a strategic opportunity to transform their operational capabilities, particularly in the case of CCPs, whose systemic relevance necessitates minimal reaction times, high precision, and seamless coordination among multiple stakeholders. Its application can mean the difference between an orderly resolution and disruption with systemic consequences.

Its main benefits include the ability to automate complex processes, simulate scenarios with greater accuracy, monitor data in real time, and facilitate cooperation between national and international institutions. These capabilities improve the technical quality of decision-making processes, reduce the risk of human error, and strengthen the traceability, transparency, and legal certainty of decisions.

As Loiacono and Rulli (2022) point out, "ResTech would eventually introduce a continuum between resolution planning and execution. A resolution authority that avails itself of ResTech might reduce the distance between the ex-ante description of the actions that would be taken in a crisis scenario, as detailed in the resolution plan, and the execution of the resolution strategy. In a ResTech framework, the difference between planned resolution actions and the actions that are actually taken can be reduced up to zero". This vision foresees a more agile, flexible and responsive decision-making environment.

However, the integration of ResTech also entails risks that should not be underestimated. Adopting technologies such as artificial intelligence, distributed ledgers and cloud platforms introduces new operational, legal and strategic vulnerabilities. These include dependence on external technology providers, opacity of algorithms in critical processes, potential exposure to cyber-attacks, and a lack of quality or adequate data governance.

Furthermore, implementing these technologies requires strengthened institutional capacities, including technological resources, specialised talent, an organisational culture open to innovation, and adaptive regulatory frameworks. Throughout this process, consideration must be given to the risk of asymmetric learning, whereby the private sector may gain an advantage over the authorities by developing and incorporating technological advances earlier, thus hindering effective public action on a level playing field.

In this process, institutional collaboration is essential. The complexity and cross-border nature of many CCPs necessitate close and continuous coordination between national, European and international authorities. Bodies such as the FSB, as well as ESMA, through its Resolution Committee (ESMA CCP ResCo), can play a catalytic role in this respect by:

– Promoting common definitions and shared operating principles.

– Advocating joint projects and networks of specialised knowledge.

– Facilitating the exchange of best practices and the harmonisation of technological approaches.

Therefore, the introduction of ResTech should be progressive and controlled, based on practical experience, through:

– Pilot projects in secure environments.

– Clear safety and oversight standards.

– Assessment mechanisms to ensure alignment with the objectives of financial stability, operational efficiency, and the protection of the public interest.

If managed effectively, ResTech could become a key component of the new resolution framework, providing an effective response to the challenges posed by an increasingly digital, complex and interconnected financial system.

In a context marked by technological acceleration and the exponential growth of data, we believe that true innovation lies not only in the tools themselves, but also in how societies collectively manage the knowledge they generate. However, as Rey (2022) warns, the indiscriminate use of automatisms and digital shortcuts can impoverish the quality of collective intelligence by prioritising quantity over intention and depth. We therefore conclude that only conscious, collaborative, and ethically oriented technological governance can harness the potential of emerging technologies – such as ResTech – and strengthen the resilience of the financial system and reinforce the legitimacy of public action in times of crisis.

Glossary of terms and institutions (alphabetical order)

Technical terminology

24/7 continuous contracting	In banking and securities markets, this refers to the ability to carry out operations or transactions, or provide certain services, continuously, 24 hours a day, 7 days a week.
Advanced analytics	A set of statistical, mathematical and artificial intelligence technologies that allow useful knowledge to be extracted from data. It is used to identify patterns, predict behaviour and inform data-driven strategic decisions.
AI (artificial intelligence)	A set of technologies that enable machines to mimic human capabilities such as reasoning, learning, perception, and decision-making. AI is used to automate processes, analyse large volumes of data and develop predictive or adaptive systems in various fields, including finance.
API (application programming interfaces)	A set of protocols that enable communication between different systems or platforms, facilitating the automation of processes between authorities or with the entities themselves.
Big data	A set of technologies and processes designed to manage and analyse large volumes of data, characterised by their variety, speed, and volume. It enables the storage and processing of both structured and unstructured data from multiple sources.
Cash calls	Extraordinary cash calls made to a CCP's members to cover losses that could not be absorbed by other mechanisms.
CCP (central counterparty)	A financial infrastructure that acts as an intermediary between parties to a financial transaction, ensuring the fulfilment of contractual obligations and reducing counterparty risk.
Cloud computing	A model for providing IT services over the internet, offering access to resources such as storage, processing, and applications, without the need for local infrastructure. It offers scalability, flexibility, and reduced technology management costs.

CMH (crisis management handbook)	An operational document that sets out the procedures, roles, teams and decisions to be taken during the resolution of a CCP.
Collaborative environments	Digital platforms that facilitate joint work between teams or institutions by enabling the sharing of information, the coordination of tasks, and real-time communication, regardless of geographical location.
Data governance	A set of standards, processes and organisational structures that ensure the quality, integrity, security and traceability of data use within an institution.
Data lakes	Centralised repositories that allow large volumes of data to be stored in their original structured or unstructured format. They facilitate advanced analytics and the use of technologies such as machine learning. They are particularly useful in environments where flexibility and scalability of data are required.
Differential privacy	A technique that introduces controlled "noise" into the data to protect individual privacy when sharing statistical results, ensuring that specific personal information cannot be identified.
DLT (distributed ledger technology)	DLT enables the storage and synchronisation of data between multiple actors in a decentralised and secure manner. Blockchain is a type of DLT.
Dry run	A type of simulation exercise without real consequences, used to test internal processes, resolution plans or collaborative tools in a controlled environment.
End-to-end simulations	Comprehensive exercises that fully and realistically recreate all the steps of a critical process, from start to finish. In the financial sphere, they are used to assess operational preparedness for crises, the coordination of authorities, and the effectiveness of resolution or risk management procedures.
Explainability/ Algorithmic opacity	The degree to which an AI system allows its decisions or predictions to be understood and justified. Its absence can hinder the oversight, accountability and legitimacy of automated processes.
Federated learning	A method of training artificial intelligence algorithms on local devices, without transferring personal data to central servers, thus protecting users' privacy.
GenAI (generative artificial intelligence)	A branch of AI that focuses on creating new content (e.g. text, data, images, audio or code) based on learned patterns. It uses advanced models, such as deep neural networks, to generate results that mimic human creativity, and has applications in areas such as automation, predictive analytics, and scenario simulation.

Homomorphic encryption	A cryptographic technique that enables mathematical operations to be performed on encrypted data without prior decryption, while preserving the privacy of the information during processing.
Injects	Elements introduced during a simulation exercise (SimEx) to alter the scenario, add complexity, and test the participants' ability to react.
Interactive dashboards	Visual tools that integrate and present key data in real time using graphs, tables and dynamic indicators. They allow users to intuitively explore information and make decisions based on up-to-date data.
LLM (large language model)	A type of artificial intelligence model that is trained on large volumes of text in order to understand, generate and translate natural language. LLMs can answer questions, write texts, summarise information and perform other complex language processing tasks. They are also a key basis for generative AI applications, such as chatbots and virtual assistants.
ML (machine learning)	A subfield of artificial intelligence that enables systems to recognise patterns in data without being explicitly programmed for each specific task.
NLP (natural language processing)	A branch of artificial intelligence that allows computers to interpret, analyse and generate human speech. It is useful, for example, for analysing regulations or drafting automated documents.
Privacy technologies	Tools and methods that allow data to be processed, analysed or shared securely, protecting sensitive information without disclosing its content. This ensures confidentiality and respect for privacy in digital environments.
Privacy-enhancing technologies (PET)	A set of technological tools designed to protect the confidentiality of data during processing, analysis or exchange. These technologies allow useful operations to be performed on data without revealing its content, which is particularly relevant in sectors such as finance, where the protection of sensitive information is paramount. The main PETs include: homomorphic encryption, federated learning, zero-knowledge proofs (ZKP), differential privacy, and secure multi-party computation (SMPC).
Quantum computing	A computational model based on the principles of quantum mechanics. It uses qubits, which can represent multiple states simultaneously, to solve highly complex processing and simulation problems more quickly and efficiently than traditional computers.

Quantum-inspired computing	A computational model that uses algorithms developed from quantum mechanical concepts, but implemented on classical computers. It mimics properties such as superposition or interference to improve performance in complex areas without requiring quantum hardware.
RegTech (regulatory technology)	Technologies used by regulated entities to meet their regulatory obligations in a more automated, efficient and traceable way.
Resolution simulators	Technological tools that recreate crisis scenarios in financial institutions in order to assess the effectiveness of resolution plans. They facilitate the identification of operational vulnerabilities and improved preparedness for real critical situations, as well as facilitating coordination between authorities.
ReSpace	Conceptual platform for a collaborative digital environment for resolution management, mentioned as an example of a practical application of ResTech.
ResTech (resolution technology)	Technologies applied to the planning, execution and monitoring of the resolution of financial institutions in crisis, with the aim of improving the process's agility, traceability and efficiency.
Robotics	Technology that uses automated systems, such as RPA, often with learning capabilities, to perform repetitive or complex tasks without direct human intervention. Examples include collecting and validating data, monitoring compliance, and executing resolution operations. Integrating it with AI enhances its ability to adapt and optimise decisions in real time.
RPA (robotic process automation)	Use of software programs (bots) to perform repetitive, rule-based tasks, such as filling in forms, generating information or sending notifications.
Sandbox (controlled environment)	Secure testing space where emerging technologies can be tested without risk to the actual system, under institutional supervision.
Secure multi-party computation (SMPC)	This technology allows several parties to jointly perform a calculation on their private data without sharing it, thereby ensuring the confidentiality of individual information.
SimEx (simulation exercise)	Planned activity that reproduces crisis scenarios in order to test the operational readiness of authorities and institutions for resolution.

SupTech (supervisory technology)	Technologies used by supervisory authorities to improve the effectiveness, efficiency and coverage of the financial supervisory process.
T+1/atomic settlement	Reduction of the settlement cycle for financial transactions to one day (T+1) or even real time (atomic settlement), which requires faster operational speed on the part of the authorities.
Tear-up	The forced write-off, in whole or in part, of offset positions, used as a resolution tool to prevent losses from accumulating at a CCP.
VMGH (variation margin gains haircutting)	A resolution tool that enables a proportional haircut to be applied to the outstanding earnings of clearing members to cover financial shortfalls.
Write-down	Write-down or conversion of debt or equity instruments to absorb losses and recapitalise an institution in resolution.
Zero-knowledge proofs (ZKPs)	Cryptographic protocols that allow a party to demonstrate that they possess certain information without disclosing its content to third parties.

Institutions and bodies

Banco de España	The national authority responsible for the prudential oversight of the Spanish banking system. It acts as a central bank, supervises the solvency of credit institutions, and cooperates with the Single Supervisory Mechanism (SSM). It also participates in the resolution of less significant entities alongside the FROB.
Central Credit Register (CCR)	Service managed by the Banco de España that collects and provides information on the credit risks that financial institutions have with their customers.
CNMV (Spanish National Securities Market Commission)	Spanish securities markets supervisory body. Its main role is to ensure market transparency, correct price formation and investor protection. It supervises investment services firms, securities issuers and regulated markets.
EBA (European Banking Authority)	It develops harmonised regulatory frameworks, assesses risks and vulnerabilities in the EU banking sector and coordinates stress tests. It also issues guidelines and technical standards for the planning and execution of bank resolutions.
ECB (European Central Bank)	Institution responsible for monetary policy in the euro area and for maintaining price stability. It also supervises the major euro area banks through the Single Supervisory Mechanism (SSM).
ESMA (European Securities and Markets Authority)	It supervises and coordinates the functioning of EU financial markets, acting as a reference point for the development of resolution policies at market level.
ESMA CCP ResCo (Resolution Committee)	This is a forum for cooperation between national resolution authorities at the European level. It is responsible for developing guidance and coordinating action on CCP resolution.
ESRB (European Systemic Risk Board)	Body responsible for macro-prudential oversight of the EU financial system. Its main objective is to prevent and mitigate systemic risks that could affect financial stability in the EU.
FROB (Executive Resolution Authority)	The authority in charge of managing the execution phase of resolution processes for credit institutions and investment services firms in Spain. It is part of the European SRM, led by the SRB. It also represents Spain before international authorities in the field of bank resolution and coordinates the national implementation of decisions taken at the European level.

FSB (Financial Stability Board)	International body that promotes global financial stability through the design and coordination of regulatory standards and supervisory practices.
IOSCO (International Organization of Securities Commissions)	It is an international body that brings together securities market regulators and aims to set global standards to improve the transparency, investor protection, efficiency, and integrity of financial markets.
SRB (Single Resolution Board)	European authority responsible for the resolution of credit institutions and certain investment firms within the Banking Union. It acts as the central body of the SRM and has full powers to plan and execute the resolution of significant or cross-border institutions, in cooperation with the national resolution authorities. Its main objective is to ensure the orderly resolution of troubled institutions while minimising the impact on financial stability, public spending, and depositors.
SRM (Single Resolution Mechanism)	It is one of the pillars of the European Banking Union. Its objective is to ensure the orderly and effective resolution of failing banks operating in the eurozone and other participating member states, thereby minimising the impact on financial stability and taxpayers. It comprises the SRB, the national resolution authorities of the participating Member States (such as the FROB in Spain), the European Commission and the EU Council. The SRM applies to significant and cross-border institutions and works in close coordination with the SSM.
SSM (Single Supervisory Mechanism)	European system of banking supervision led by the ECB, in cooperation with the competent national authorities. It directly supervises the major banks in the eurozone to ensure the soundness of the banking system and consistent supervision across the Banking Union.

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