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The Digital Euro and Financial Stability*:*
Could a CBDC cause a "Digital Bank Run" in the Eurozone?

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INTRODUCTION:

Background, Motivation, and Objectives of the Study

The landscape of the European financial system is undergoing a huge shift as physical cash usage is declining rapidly. Meanwhile, digital payments are managed by private, often foreign intermediaries that have taken over the market. To protect the foundation of public money in this digital era, the European Central Bank (ECB) is actively developing the Digital Euro. This retail Central Bank Digital Currency (CBDC) promises a secure and frictionless payment method for everyday life. Yet, it introduces a profound structural threat to the existing banking sector.

The core motivation for this research is driven by the dangerous macroeconomic consequences of giving the public a risk-free digital alternative to commercial bank deposits. If citizens can instantly transfer their savings into central bank liabilities with a simple tap on a smartphone, the physical friction that historically stopped bank runs simply disappears. This reality creates the risk of a lightning-fast “digital bank run”. To avoid such threats, policymakers proposed a strict €3,000 holding limit per citizen, but the effectiveness of this mathematical limit remains heavily debated.

The main objective of this study is to evaluate whether this €3,000 holding limit is actually enough to protect the financial stability of the Eurozone. This research analyzes the theoretical part of financial intermediation alongside the empirical liquidity data from real commercial institutions. The goal of this research is to mathematically evaluate the maximum potential systemic drain, aiming to determine if this regulatory market stabilizer can prevent widespread insolvency, paying special attention to the highly unequal impact this shock would have on Tier-1 commercial banks versus small and mid-tier regional banks.

Structure of the Study

For reaching these objectives, this research is split into three main chapters. Chapter 1 demonstrates the foundation of the Digital Euro, detailing the accelerated shift towards digital payments, and defining the technical architecture of the currency and breaks down the debated €3,000 holding limit. Chapter 2 shifts the focus to banking stability. It applies the Diamond-Dybvig model to explain traditional financial intermediation. Then, it analyzes how modern mobile banking applications can speed up the process of deposit flights and explores the macroeconomic dangers of commercial disintermediation. Finally, chapter 3 conducts the empirical analysis as it extracts historical Liquidity Coverage Ratio (LCR) data from important European banks to build a reliable baseline. Then, a predictive mathematical model is run to simulate deposit outflows across three distinct consumer behavior scenarios, to reveal how the holding limit drives the survival of the commercial banking sector.

Chapter 1: The Digital Euro

1.1 Context: The Rise of Digital Payments

Today, the financial world is going through a huge shift, maybe the biggest one since paper money was introduced. Everything is digital now, and physical cash is losing its dominance. In fact, the report by the Capgemini Research Institute (2024) indicates that Europe's non-cash transactions reached 361 billion in 2023, with a 15.5% YoY increase in 2024 and a projected 12% compound annual growth (CAGR) from 2023 to 2028. With the younger generation preferring everything to be done digitally, the older generation is adapting to it because it is faster and more convenient. It is not just a technical change, but rather represents a significant shift in consumer habits, creating new challenges for governments trying to control their own currency.

The European Central Bank (ECB) is closely monitoring how Europeans use money in their daily lives because it is a real issue for them nowadays. Europeans are using their phones and cards because they are easier and more convenient, meaning that physical money is slowly fading away. In fact, the ECB's study on the payment attitudes of consumers in the euro area (2022a) reports that cash was used in 59% of POS transactions in 2022, down from 72% in 2019. Cash is still helpful for smaller purchases but the way it's going is clear and straightforward. Europe is moving fast towards a digital economy where coins and paper money will no longer be the main payment method.

As people use less cash, private companies are taking a bigger role in handling payments. For example, when a consumer buys a coffee in Milan using a smartphone, they are no longer paying with public money anymore, but using private money managed by banks and big apps. Fabio Panetta (2022), a former member of the ECB Executive Board, said this could be risky because we must preserve the role of 'public money as the anchor of

the payments system'. In the past, cash connected people directly to the central bank. Cash is also the safest money because it is backed by the government and not by private companies that could fail.

Europe is facing a massive problem because it relies way too much on private payment systems. Most of these apps are actually run by big international companies from outside the EU, which is risky. If their systems go down, European citizens and businesses could literally be left with no way to pay for anything. This is a huge threat to economic stability. In 2023, Fabio Panetta argued that 'we are designing it as a safe payment tool in order to preserve the role of public money – that is, money backed by the state – while balancing innovation in payments with the stability of the financial sector and guaranteeing privacy'. To protect the economy, European policymakers realized that they need a digital version of public money. This is the main reason the ECB is developing the Digital Euro. It is meant to be a safe, public option for everyone just like physical cash.

Another big reason for this change is when the COVID-19 pandemic hit and the virus spread everywhere, leading to people not wanting to touch any kind of physical money because of health concerns. This worry made countries that liked using cash to switch and start using cards and digital payments. Italy for instance. In the past, Italians liked using cash for everything, but the pandemic changed things a lot. The European Central Bank (2021) observed that the health emergency significantly accelerated the adoption of digital payment methods across the euro area. The Bank of Italy's analysis of the ECB's 2022 SPACE survey revealed that the share of cash payments at points of sale (POS) in Italy dropped to 69% in 2022, down from 82% in 2019 (Banca d'Italia, 2023). These facts show just how fast things are moving. Even after lockdowns, people stayed with cards

rather than going back to cash. With payment habits and methods changing so quickly, the ECB now faces a difficult task in designing a Digital Euro that works for everyone.

To sum up, the situation in the Eurozone is very important right now. The way people pay for things has changed a lot, and the traditional financial system is having trouble keeping up. Depending only on private apps and international card companies is risky for Europe's economy in the future. The European Central Bank understands this and knows it is important to act quickly. In their latest big report, the European Central Bank (2025) said 'As payment habits evolve, and cash payments decline compared with digital transactions, the need for a public digital means of payment – complementary to cash – has become increasingly urgent' (European Central Bank, 2025a). This is why the Digital Euro project started. The main goal is not just to make another payment app, but to protect public money for the future. The European Central Bank (2025) also says, 'A digital euro will ensure that people enjoy the benefits of cash also in the digital era. In doing so, it will enhance the resilience of Europe's payment landscape, lower costs for merchants, and create a platform for private companies to innovate, scale up and compete' (European Central Bank, 2025b). This shows why Europe needs the Digital Euro. The old system is going away, and a new public solution is needed to help the economy. Now that this is clear, the next step is to explain what the Digital Euro is and how it will work in real life.

1.2 Definition: What is a Digital Euro

A clear definition of the Digital Euro is important for understanding how it could affect the European banking system. The Digital Euro is a retail Central Bank Digital Currency (CBDC) issued by the ECB. It is an alternative for cash offering the public an accessible way to the digitalization process, 'citizens and firms continue to have access to the safest

form of money, central bank money' (European Central Bank, 2021). The Digital Euro is supported by the state's central authority unlike cryptocurrencies which are volatile and decentralized, or private stablecoins which can be unstable. The Digital Euro is listed as a liability on the Eurosystem's balance sheet, 'a riskless, accessible, and efficient form of digital central bank money' (Banca d'Italia, 2021). Meaning that the Digital Euro will have the value of traditional fiat currency excluding the risks found in privately issued digital money. Having a Digital Euro is economically and legally the exact same thing as having cash in hand, but in a more convenient digital form.

To fully appreciate the impact the Digital Euro could have, it is important to distinguish it from existing digital payment methods. The money kept in commercial bank accounts which are accessed through mobile banking apps and ATMs are classified as commercial bank money. The European Central Bank specifically explained that 'commercial bank money (bank deposits) originates from, and circulates within, the private sector and is called "inside" money' (European Central Bank, 2025c). This form of money is an entry on the bank's ledger, and represents the bank's obligation to provide cash for customers if requested. Central bank money is completely separate from commercial banks. According to the ECB, as a sovereign liability, 'these reserves are the ultimate safe asset: there is zero credit risk' (European Central Bank, 2025c). It is important for people to also see both commercial and central bank money are functionally similar. As the ECB said, 'central bank money and commercial bank money are intertwined: indeed, it is essential that households and firms view these as equivalent' (European Central Bank, 2025c). The Digital Euro gives the public direct access to this risk-free central bank money, which was once available to commercial banks with central bank accounts.

Even though the structural reality of the Digital Euro being a direct liability of the Eurosystem, the central bank has no operational desire nor logistical capacity to transform into a big retail banking institution. From managing daily financial interactions of hundreds of millions of European citizens including the Know Your Customer (KYC) protocols to performing Anti Money Laundering (AML) monitoring, and providing 24/7 customer support. All of these fall entirely outside the mandate and infrastructure of a central bank. To solve this operational challenge, the Digital Euro relies on a strict two-tiered distribution architecture. The official project framework established early on that ‘supervised private intermediaries would be best placed to provide ancillary, user-facing services and to build new business models on its core back-end functionality' (European Central Bank, 2020). Therefore, the ECB will manage the core settlement ledger and the issuance of the currency strictly, while private entities like commercial banks and authorized Payment Service Providers (PSPs) will handle customer relations. The ECB mentioned that 'Supervised intermediaries would perform all end user facing roles such as opening digital euro accounts or wallets and associated payment operations' (European Central Bank, 2022b). This model is designed to protect the private sector’s role in financial intermediation, ensuring that commercial banks remain the primary channel between the monetary authority and the retail public, while preventing the central bank from unfairly competing in the payment services market.

One of the Digital Euro’s characteristics is being able to imitate the tangible properties of cash when it comes to user privacy, environmental impact, and offline transaction capabilities. The digital transition of payments has raised serious concerns regarding surveillance and the commercial exploitation of personal financial data. However, the architecture behind the Digital Euro contains mechanisms that allow transactions to

happen independently without an internet connection or a real-time central ledger validation. But technical reports confirm that this requires ‘settlement via local storage devices' (European Central Bank, 2022c), which allows peer-to-peer transfers where the details of the transaction are exclusively between the payer and the payee, exactly like handing someone a physical note. Moreover, from an operational standpoint, the Eurosystem made sure that the underlying infrastructure avoids the huge energy consumption accompanied with blockchain-based private currencies. Provisional tests conducted by the Bank of Italy proved that 'the power used to run tens of thousands of transactions per second is negligible compared with the energy consumption of crypto-assets such as bitcoin' (Banca d’Italia, 2021). For that reason, the Digital Euro’s is defined not by its legal status, but rather by its technological framework that is designed to protect user privacy and maintain environmental sustainability while having the modern concept of sovereign cash.

Eventually, this widespread and frictionless access to the safe and digitized central bank money to the public can create a direct and highly competitive force against commercial bank deposits. If the public can convert their standard bank deposits into a risk-free alternative instantly with a simple screen tap, the stability of the intermediated financial system is brought into serious question. A huge shift in funds from commercial banks into the Digital Euro accounts would take away the primary funding source of banks, and could result in restricting their ability to issue loans to households and businesses, which could lead to a liquidity crisis. In contrast, monetary authorities counteracted this exact scenario by proposing structural constraints. The ECB stated that 'the envisaged design of a digital euro would address financial stability concerns by applying adequate holding limits ' in order to 'prevent the materialisation of high deposit outflows' (European Central

Bank, 2023). This regulatory framework is implemented to keep the Digital Euro's main focus on daily payments rather than acting as a large-scale store of value, theoretically protecting the banking sector from disintermediation. However, will these artificial boundaries be enough to prevent a liquidity crisis during a financial panic?

1.3 Stability: Is a €3000 holding limit enough?

To reduce the risk of massive deposit flights from the commercial banking sector into the Eurosystem, policymakers proposed to implement strict quantitative constraints on the amount an individual can hold of the Digital Euro. The suggested and mostly debated figure per citizen is a hard limit of €3000. This limit was not chosen randomly but rather statistically validated to accommodate the retail payment requirements of the majority of European consumers while theoretically preventing this new currency from being exploited as a large-scale store of value. Fabio Panetta, presenting the Eurosystem's primary design to the European Parliament stated that 'a threshold of €3,000 would be more than the amount of cash most citizens hold today and would be above ´the average monthly wage in most euro area countries' (Panetta, 2021). From a macroeconomic perspective, introducing a holding limit (H) caps the theoretical maximum deposit outflow ($O_{!"\#.}$) from the commercial banking system. Mathematically, if we define N as the total number of individual depositors in the Eurozone and D_{0} as the current commercial bank deposit balance of an individual citizen i, the maximum aggregate outflow can be modeled using the following bounded summation:

$$O_{!"\#} = \sum_{\$\&'}^{\%} \min(D_{\$}, H) \qquad 1.1$$

By implementing H at €3,000, the Eurosystem aims to place a mathematical ceiling on potential outflows, making sure that large-scale shifts of capital by hight-net-worth individuals or corporations do not destabilize the commercial banking sector's liquidity. However, a €3,000 limit may seem like a guarded figure on an individual basis, the aggregate statistical impact across the entire European banking union represents a significant potential liquidity shock. The Eurozone accommodates over 340 million citizens and if a large amount of this population adopts the Digital Euro and maxing their allowed holding limit, the cumulative withdrawal of "inside money" would be uncommon. The European Banking Federation (EBF) conducted severe stress-testing models on this exact limit and issued an extreme warning regarding the macroeconomic mathematics. The EBF formally stated that 'With the holding limit at 3,000, we find that the digital euro can realistically lead to an outflow of up to 739 billion euro of bank deposits in the euro area' (European Banking Federation, 2023). To put this into perspective, €739 billion represents around 7% to 9% of total retail deposits in the entirety of the Eurozone. If commercial banks lose this huge volume of retail funding, they will be forced to rebalance their liabilities by turning to wholesale financial markets or issuing debt securities because wholesale funding is statistically more expensive and unstable compared to retail deposits. Profitability of commercial banks would experience a direct contraction, and this margin reduction would be going towards the real economy through higher interest rates on mortgages and corporate loans, which can hinder economic growth.

In addition to structural profitability, the €3,000 limit raises a mathematical threat to the mandatory ratios established by the Basel III framework, especially the Liquidity Coverage Ratio (LCR). As established by the Basel III framework, the legal objective of

the LCR is to ensure 'that banks have an adequate stock of unencumbered high-quality liquid assets (HQLA) that can be converted easily and immediately in private markets into cash to meet their liquidity needs for a 30 calendar day liquidity stress scenario' (Basel Committee on Banking Supervision, 2013). The ratio is expressed as:

$$LCR = \frac{HQLA}{Total\ Net\ Cash\ Out\ Flows\ over\ 30\ days} \geq 100\% \qquad 1.2$$

Although a withdrawal of €3,000 from an individual might seem too small to threaten a bank's solidity, the aggregate effect causes a drain on the bank's central bank reserves. When retail clients switch their commercial deposits into Digital Euros, commercial banks have to settle these transactions by transferring their own reserves to the European Central Bank. Because central bank reserves are the main key of High-Quality Liquid Assets (HQLA), this massive switch directly reduces the numerator of the LCR equation. If millions of citizens in the EU practice their right of transferring the €3,000 limit into their Digital Euro wallets at the same time, the denominator (Total Net Cash Outflow over 30 days) expands rapidly. To keep the LCR above the 100% threshold, commercial banks would be forced to increase their holdings of the HQLA significantly (like government bonds), and reduce their issuance of illiquid assets (like long-term commercial loans). The Bank for International Settlements (BIS), observing the vulnerabilities across global Central Bank Digital Currency (CBDC) projects, noted that 'a CBDC could also affect existing financial market structures and business models, which may pose risks to financial stability' (Bank for International Settlements, 2021).

Moreover, recent macroeconomic studies assessing this deposit flight confirmed that 'the academic literature broadly echoes policy makers' concerns about bank disintermediation and financial stability risks' (Ahnert et al., 2022). As a result, even though a €3,000 limit prevents a total collapse, it forces a restructuring of commercial bank assets.

To make sure that the €3,000 cap does not hinder large transactions, the ECB introduced a liquidity management system. The European Central Bank states that 'users would be able to seamlessly link their digital euro account to a payment account with their bank, enabling a "reverse waterfall" mechanism' (European Central Bank, 2024). This allows a large payment to be done instantly by draining the digital wallet and to pull any remaining gaps directly from the commercial bank account. Furthermore, the ECB established that 'merchants would be able to receive and process digital euro, but would not be able to hold them at all – protecting the corporate deposit base of the banking system' (European Central Bank, 2024). Finally, the €3,000 cap, the reverse waterfall mechanism, and the zero-holding corporate limits ensure that the Digital Euro functions as a daily means of payment rather than a store of value.

Chapter 2: Banking Stability

2.1 Financial intermediation: The Diamond-Dybvig Model 1983

To fully understand the risks a retail Digital Euro creates for the banking sector, it's important to understand the mechanics of traditional commercial banking. The framework for modern financial intermediation was structured in the seminal 1983 paper by Douglas Diamond and Philip Dybvig. Essentially, the Diamond-Dybvig model shows mathematically how banks create economic value by acting as intermediaries between depositors who want immediate access to their funds, and borrowers who want long-term capital. The authors established that 'bank deposit contracts can provide allocations superior to those of exchange markets' by 'providing better risk sharing among people who need to consume at different random times' (Diamond and Dybvig, 1983). This process is known as maturity transformation. It is when commercial banks take short-term deposits and lends them out as long-term investments (such as mortgages or corporate loans). On the other hand, while this intermediation is the heart of macroeconomic growth, the authors specifically explained how 'the transformation of illiquid assets into liquid liabilities' provided by banks can 'leave banks vulnerable to runs' (Diamond and Dybvig, 1983). Because most of the bank's capital is locked in long-term investments, the bank would never be able to liquidate its assets fast enough to repay all depositors at the same time if a panic occurs, which will lead to the bank's collapse leaving depositors without their savings.

To illustrate this vulnerability mathematically, the Diamond model is structured around three economic periods: $t = 0$, $t = 1$, and $t = 2$. From this perspective, all agents are at the same planning period ($t = 0$) but their decisions are still unclear regarding when they will actually need their deposit. A section of these consumers (symbolized as p) will

discover that they are “impatient” and continue to withdraw their funds to consume early at $t = 1$. The remaining section of consumers $(1 - p)$ are “patient” and can boost their returns by waiting to consume at $t = 2$. Because the consumers don’t know whether they are “patient” or “impatient” at $t = 0$, the bank pools both deposits and liquidity risk. The utility function of a consumer at $t = 0$ is expressed as:

$$U = P \cdot u(c_2) + (1 - P)u(c_1) \qquad 2.1$$

In this function, c_1 and c_2 represent the consumption at periods 1 and 2, in that order, and $u()$represents the increasing utility function. The original paper stated that by pooling these resources, the bank essentially provides insurance against the need to consume early (Diamond and Dybvig, 1983). Yet the trigger for a bank run happens if a rumor spreads that a bank is failing. If this happens, even patient consumers $(1 - P)$ will panic and rush to withdraw their money at $t = 1$. Because the bank’s capital is locked into long-term investments which are aimed for the second period $(t = 2)$, the bank will not be able to meet the consumers’ demand of withdrawing which will cause a complete bank failure.

To avoid such a disaster, the Diamond-Dybvig framework highlights several solutions to eliminate the encouragement for patient consumers to panic. The first and best solution is the introduction of a central bank authority, meaning that a Central Bank would act as a lender of last resort, or for the CB to implement a state-backed deposit insurance scheme. If the patient depositors are sure that their savings are protected no matter what kind of panic happens, the self-reinforcing belief of a bank run is broken. Diamond and Dybvig specifically concluded that 'government provision of deposit insurance can produce superior contracts' capable of preventing runs entirely (Diamond and Dybvig, 1983). Otherwise, if a panic has already started, authorities can carry out a temporary

freeze on withdrawals to prevent the early liquidation of long-term assets. However, while these traditional macroeconomic solutions were highly effective against physical bank runs, the new technological framework of the modern financial systems will introduce a new challenge.

2.2 The Digital Run: How mobile apps and instant transfers increase the speed of depositing

While the Diamond and Dybvig model outlines the mechanics of a bank run, its historical application was always dependent on physical friction. In 1983, panicking depositors were constrained by the need to visit the bank's branch physically, queue outside, and withdraw banknotes. Today, the increase of smartphones and instant payment networks has eliminated the physical friction that was necessary before. Commercial banking is now instantly accessible via mobile applications, essentially altering the speed of liquidity crisis. Recent research published by the European Central Bank observed that 'During stress episodes, deposits may become flightier, further amplified by negative newsfeed as retail customers can react immediately by accessing their bank account online or via smartphone' (Fascione et al., 2025). When a central bank digital currency is introduced into this already digitized environment, the danger multiplies. Unlike physical cash, which is inefficient to store, a retail CBDC delivers a risk-free alternative that is just one tap away. The Bank for International Settlements (BIS) explicitly warned that 'a widely available CBDC could make such events more frequent and severe, by enabling "digital runs" towards the central bank with unprecedented speed and scale' (Bank for International Settlements, 2020). Developing on this exact vulnerability within the Eurozone, the ECB stated that 'in crisis situations, when savers have less confidence in the whole banking sector, liquid assets might be shifted very rapidly from commercial

bank deposits to the digital euro' (European Central Bank, 2020). Therefore, the digital bank run is not defined by physical crowds anymore, but rather by the instantaneous speed of smartphone applications transferring billions just one tap away.

To prove that this technological progress is not just only a theoretical threat, the SVB crisis provides evidence of a modern digital bank run. On a single day (March 9, 2023), panicked depositors accessed online banking portal and mobile applications to start an astonishing $42 billion in withdrawals. The Basel Committee on Banking Supervision analyzed this structural failure and stated that 'unprecedented speed of deposit withdrawals' as a main trigger for the widespread panic between depositors (Basel Committee on Banking Supervision, 2023). Unlike normal bank runs that usually happens over several weeks, modern digital infrastructure allowed the SVB panic to a fatal level almost instantly. The Financial Stability Board confirmed the severity of this technological shift, noting in their report that the major deposit runs in March 2023 experienced outflows of around 20-30% per day. The Board warned that it was unprecedented in some cases and was faster than the previous bank runs (Financial Stability Board, 2023).

The SVB collapse showed that digital banking’s easy access has removed the physical friction that once was a pillar stabilizing traditional banking crises. When this rapid mobile technology is combined with a retail central bank digital currency, the systemic danger reaches its absolute peak. Because a Digital Euro provides a completely risk-free, instantaneous alternative to commercial deposits, the speed of a potential panic would be mathematically impossible for commercial banks to survive under the traditional Diamond-Dybvig framework. The Bank for International Settlements specifically warned that 'Bank runs might occur more quickly if the public were able to easily convert

commercial bank money into risk-free central bank liabilities' (Bech and Garratt, 2018). While the €3,000 holding limit discussed in Chapter 1 attempts to cap the absolute volume of this flight, the underlying technological reality remains that digital immediacy permanently alters the stability of commercial deposits.

2.3 Disintermediation Risk: Implications for commercial lending and investment

This ongoing threat of digital deposit flight directly leads to the risk of disintermediation, which jeopardizes the key macroeconomic function of commercial lending. If retail deposits from commercial banks got deposited quickly into Digital Euro wallets, banks lose the main funding required to issue long-term mortgages and corporate credit. To understand why losing these intermediaries would be devastating for the real economy, the delegated monitoring model introduced by Douglas Diamond in 1984 is the right move. In a capital market without banks, direct lending suffers from severe market failure and high transaction costs. If an entrepreneur requires capital from multiple investors (m), every investor has to independently pay a monitoring cost (c) to make sure the borrower does not claim failure to keep extra return. This creates a huge duplication of efforts which can result in total direct monitoring costs of $m \times c$. To solve this market imperfection, investors delegate the monitoring task to a central intermediary (Commercial Banks) to avoid the cost of duplication. However, if the bank only finances a single project, a new problem comes to life: who monitors the monitor? Because investors do not fully trust the intermediary, they require a premium (k) that initially makes intermediation more expensive than direct lending (monitoring the monitor problem). The mathematical

solution relies heavily on the Law of Large Numbers (LLN): as the number of financed projects approaches infinity ($n \to \infty$), the bank's aggregated returns become highly predictable and stable. By diversifying across many different loans, the bank basically eliminates risk. The original paper establishes that 'diversification within an intermediary serves to reduce these costs, even in a risk neutral economy' (Diamond, 1984). This financial architecture allows banks to process transactions at lower costs than independent agents doing all the work, which is exactly why securing their commercial deposits is important for allocating macroeconomic resources efficiently.

To show how the intermediary solves this trust deficit and eliminates the required premium mathematically, the Diamond model relies on the expected return function of the commercial bank's aggregated portfolio and it is expressed as:

$$\mu = P \cdot H + (1 - P) \cdot L \qquad 2.2$$

As shown, the expected average return (μ) is determined by the probability (P) of a successful project that yields a high return (H), combined with the probability of failure ($1 - P$) that yields a low or liquidated return (L). If a bank issues only a few loans, it remains risky as the outcome is not predictable nor stable, but when the bank aggregates thousands of these loans using a massive base of retail deposits, the number of financed projects approaches infinity ($n \to \infty$). Through diversification, the bank's actual aggregated return merges perfectly on the expected average (μ), diversifying away that risk. Because the returns become highly predictable and stable, depositors trust the intermediary, therefore the monitoring premium (k) drops to zero, and the bank successfully provides credit at a lower transaction cost than direct market lending.

Nevertheless, the architectural framework could collapse in its entirety if the commercial bank loses its stable deposit funding. If the introduction of the Digital Euro triggers the rapid digital bank runs mentioned in Subchapter 2.2, commercial banks will experience extreme contraction in their available capital. Without a stable pool of retail deposits, commercial banks cannot fund enough loans to reach the mass required for diversification. If the number of projects (n) decreases, the Law of Large Numbers (LLN) fails, commercial banks can no longer take monitoring costs, and transaction costs for the real economy skyrocket. Leading global financial institutions have recognized this specific weakness. Ulrich Bindseil, the ECB's Director General of Market Infrastructure warned that 'CBDC, if highly successful, would disintermediate in a structural way the banking system' (Bindseil, 2020). Because a central bank cannot replace commercial banks in performing micro-level delegated monitoring for millions of local businesses, the disintermediation would cause a freeze in corporate credit and mortgages. The research published by the International Monetary Fund (IMF) analyzed this threat and concluded that CBDC's 'could lead the central bank to engage in large-scale intermediation, thus competing with private financial institutions for deposits, with potentially negative consequences for the availability of bank credit, economic activity, and overall financial stability' (Popescu, 2022). The European Central Bank has repeatedly acknowledged that a retail digital currency must be restricted to 'avoid potential undesirable consequences of its issuance, thereby limiting any diverse effects on monetary policy and financial stability, and on the provision of services by the banking sector, as well as mitigating possible risk' (European Central Bank, 2020).

Chapter 3: Empirical Analysis

3.1 Methodology: Data Extraction and Selection of Systemically Important Banks (SIBs)

Since the theoretical framework and mathematical formula of the Liquidity Coverage Ratio (LCR) that have been outlined in Section 1.3, this chapter shifts into practical application. The methodology of this empirical analysis focuses highly on extracting historical data from the annual financial reports of major commercial European banks. By separating the reported High-Quality Liquid Assets (HQLA) and the Total Net Cash Outflows from 2016 to 2022, this study establishes a quantitative baseline of market health. This historical baseline will be then manipulated in Section 3.3 to mathematically simulate the systematic shock of deposit flights triggered by a frictionless Digital Euro.

To create a reliable comparative baseline of healthy banks, this study selects Intesa Sanpaolo as the representative for the domestic Italian market and BNP Paribas for the broader European Union. These Tier-1 banking groups were chosen due to their classification as systematically important institutions and their consistent history of maintaining liquidity buffers far above the 100% threshold. In Intesa Sanpaolo's official financial report in 2023, they explicitly said that its market survival was supported by 'a solid capital base that is well above the prudential requirement, a strong liquidity position, a diversified business model, careful management of operating costs, the quality of its assets, and attention to its people' (Intesa Sanpaolo, 2023). Tracking these strong LCR levels provides a stable benchmark of how well-capitalized banks absorbs standard macroeconomic shocks.

On the contrary of healthy baselines, the methodology includes ABLV Bank— a Latvian bank fully operating within the Eurozone but under the direct supervision of the European

Central Bank, as a textbook historical model of severe liquidity distress. In 2018, a sudden shock triggered a huge and rapid bank run that completely drained the bank's central reserves in a matter of days, and the European Central Bank declared that the bank as failing in its official regulatory assessment, and confirmed that 'the bank experienced an abrupt wave of withdrawal of deposits' and formally concluded that 'Due to significant deterioration of its liquidity, the bank is likely unable to pay its debts or other liabilities as they fall due' (European Central Bank, 2018). Including the rapid collapse of this bank demonstrates the powerful speed of a modern deposit flight, and underlining exactly what could happen to commercial banks if the Digital Euro is introduced without strict holding limits.

3.2 Data Analysis: Comparative Assessment of Historical Liquidity Trends (2016-2022)

To evaluate the robustness of the selected institutions, Table 1 presents the historical Liquidity Coverage Ratio (LCR) data extracted from 2016 to 2022:

YEAR	INTESA SANPAOLO	BNP PARIBAS	ABLV BANK
2016	>100% (Compliant)	>100% (Compliant)	>100% (Compliant)
2017	>100% (Compliant)	>100% (Compliant)	>100% (compliant)
2018	>100% (Compliant)	>100% (Compliant)	Failed (Liquidity Crisis)
2019	>100% (Compliant)	>100% (Compliant)	N/A (Liquidated)
2020	159.1%	>100% (Compliant)	N/A (Liquidated)
2021	184.5%	>100% (Compliant)	N/A (Liquidated)
2022	>100% (Compliant)	>100% (Compliant)	N/A (Liquidated)

An analysis of Intesa Sanpaolo's financial reporting from 2016 to 2022, it reveals a profound capital adequacy within the Italian domestic market. Mirroring the comparative data in Table 1, Intesa Sanpaolo consistently maintained its Liquidity Coverage Ratio (LCR) well above the Basel III mandatory threshold of 100%. In 2016, Intesa Sanpaolo was already compliant above this baseline requirement. Fast forward to 2020, when the

global macroeconomic shock of the COVID-19 pandemic triggered massive market fluctuations, Intesa's liquidity buffer was astonishing, as it retained exquisite deposit levels during the pandemic and post-pandemic periods. The bank officially reported LCR spiked to phenomenal anomalies of 159.1% in 2020 and 184.5% in 2021. In its official 2022 annual report, they mentioned that its operational resilience is driven by the fact that 'The goal is to create sustainable, long-term value for the benefit of shareholders, our people, our customers, the community and the environment' (Intesa Sanpaolo, 2023). This proves that under both normal conditions and severe external stress, a Tier-1 commercial bank is well-capitalized against standard deposit fluctuations.

Mirroring Intesa Sanpaolo's domestic performance, BNP Paribas serves as the indicator for broader Eurozone stability as the largest banking group in Europe (excluding the United Kingdom), the French institution maintained a high, well-capitalized liquidity position that remained securely above the minimum 100% Basel III mandatory threshold throughout the entire 2016 to 2022 period. Regardless of the severe economic pressures of the global pandemic and its aftermath, public trust in the institution remained absolute, allowing the bank to effortlessly retain its massive deposit base. By the end of 2022, and while continuing to operate as the biggest bank in the European Union, BNP Paribas officially confirmed in its annual report that its 'liquidity remained solid, with a Liquidity Coverage Ratio (LCR) of 211% at 31 December 2022' (BNP Paribas, 2023). This consistent regional performance backs up the theory that well-established, high-trusted commercial banks are fundamentally stable under routine market pressures.

Apart from the resilient baselines discussed earlier, the ABLV Bank clearly shows the disastrous velocity of a modern bank run. To begin with, the Latvian institution appeared entirely stable on paper, maintaining an LCR above the 100% threshold and remaining

fully compliant with standard European Central Bank supervision throughout 2016-2017. However, in February 2018, a sudden shock to depositor confidence triggered an aggressive, instantaneous deposit flight. Because modern banking relies on fractional reserves, the bank simply did not possess enough liquid cash to match the sheer speed of customer withdrawals. After the liquidity failure, the European Single Resolution Board (SRB) officially stepped in, and in their final regulatory decision, the SRB concluded that 'resolution action is not in the public interest' and officially ordered that the 'winding up of the banks will take place under the law of Latvia' (Single Resolution Board, 2018). This ruling forced the bank into total liquidation from 2019 through 2022. The rapid downfall of ABLV Bank serves as a crucial historical lesson, it proves that even fully compliant banks can be destroyed in days if deposit outflows occur too rapidly.

3.3 Results: Estimating Potential Deposit Outflows Under Digital Euro Implementation

While Section 1.3 showed the theoretical mechanisms of the Digital Euro, this section provides a quantitative estimate of potential liquidity outflows from commercial banks. To show the structural impact of a Central Bank Digital Currency (CBDC) on retail deposits, the analysis employs an observation-based predictive framework on official macroeconomic aggregates from the European Central Bank.

The total systemic deposit outflow ($O_{O(*+}$) is expressed as a function of the total eligible population (N), the citizen adoption rate (α), and the mean cash balance maintained for every active digital wallet (H). This relationship is expressed through the following rule-based calculation:

$$O_{)*)"+} = N \cdot \alpha \cdot \mathrm{H} \qquad 3.1$$

To make this estimate realistic, the baseline parameters are established using current Eurozone data. The total eligible population (N) stands at approximately 344 million citizens, and the total overnight household deposits currently held by the European commercial banking sector equals €8.5 trillion. Finally, the critical regulatory variable in this equation is the individual holding limit (L) which the ECB gas proposed capping at €3,000 per citizen to restrict unlimited capital flight.

Table 2 shows the projected liquidity drain across three specific consumer scenarios: Routine Use, a Moderate Shift, and a Systemic Panic:

Scenario	Consumer Behavior	Average Digital Balance (H)	Estimated Total Outflow (O_{total})	Percentage of Total Deposits (€8.5T)
Routine Use	Day-to-Day transactional spending	€500	€172 Billion	~2.0%
Moderate Shift	Partial transition of savings	€1,500	€516 Billion	~6.1%
Systemic Panic	Maximum flight to safety	€3,000	€1.03 Trillion	~12.1%

Under normal economic conditions, looking first at the Routine Use, the public would primarily treat the Digital Euro as a simple tool for everyday shopping rather than long-term wealth accumulation, assuming that the average citizen maintains a €500 balance in their Digital wallet, the total projected outflow is calculated as:

$$O_{)*)"+} = 344{,}000{,}000 \cdot 500 = 172{,}000{,}000{,}000 \qquad 3.2$$

Next, comparing this €172 billion figure to the massive €8.5 trillion pool of Eurozone retail deposits reveals the actual impact:

$$Impact = \frac{172{,}000{,}000{,}000}{8{,}500{,}000{,}000{,}000} \approx 0.0202 \qquad 3.3$$

This translates to roughly a 2% drop in total deposits. Major commercial banks handle this kind of 2% drop routinely during normal business operations. Meaning that they possess enough cash on hand to easily cover the difference without having to liquidate their assets.

At this low level of outflow, the financial impact stays completely uniform across the commercial banking sector. Big financial institutions in Europe handle a drop of 2% like a standard practice during normal operations, and small to medium commercial banks can

easily absorb such minor shifts using their existing cash reserves. It creates a small structural tightening across the board, but it poses no operational risk or threat of insolvency to smaller financial institutions.

The Moderate Shift scenario models a completely different consumer behavior. Instead of just daily spending, the public begins holding partial saving in their central bank wallets. Pushing the average balance up to €1,500 creates a much heavier drain on commercial reserves:

$$O_{)*)"+} = 344{,}000{,}000 \cdot 1{,}500 = 516{,}000{,}000{,}000 \quad 3.4$$

Dividing that €516 billion outflow by the €8.5 trillion baseline shows the true systemic weight of this behavioral shift:

$$Impact = \frac{516{,}000{,}000{,}000}{8{,}500{,}000{,}000{,}000} \approx 0.0607 \quad 3.5$$

This translates to a 6.1% drop in total Eurozone retail deposits. Losing 6% of deposits restricts commercial liquidity, but it still falls strictly short of triggering a crisis. Major commercial banks can still comfortably clear this Basel III regulatory requirements in

case of a Moderate Shift. They would simply need to adjust their wholesale funding strategies to make up for the missing retail cash.

This 6.1% drop is a sharp divide that opens up across the financial sector. Tier-1 commercial banks can easily absorb this drop using their deep structural liquidity buffers. However, small and mid-sized commercial banks begin to face real pressure as losing 6% of their retail deposit base forces them to go out and hunt for expensive wholesale funding just to stay balanced. This heavily damages their profit margins and it pushes them dangerously close to operational distress. Although it usually stops short of causing outright insolvency, they only survive because they can still pledge their remaining eligible assets to the central bank in exchange for emergency cash. However, this specific level of liquidity loss for small and medium sized commercial banks represents their absolute maximum breaking point, any further drain beyond this 6% threshold would completely destroy their available collateral, eventually pushing them into regulatory failure and outright insolvency.

The Systemic Panic scenario is the ultimate test for financial stability. A severe economic shock that completely invades the trust of the public. Citizens rush naturally to convert or transfer their savings into the risk-free central bank money, and a frictionless Digital Euro can make these transfers happen instantly. To calculate the worst-case scenario, the model sets the adoption rate (α) to 1.0 (100% participation). A worst-case scenario is that the entire European population panics simultaneously and they max out their digital wallets to the €3,000 limit. At this point, the total liquidity outflow hits a hard mathematical ceiling:

$$O_{?@?AB} = 344{,}000{,}000 \cdot 3{,}000 = 1{,}032{,}000{,}000{,}000 \quad 3.6$$

When applying this massive €1.032 trillion flight to safety against the baseline deposit pool, it shows the absolute maximum systemic drain:

$$Impact = \frac{1{,}032{,}000{,}000{,}000}{8{,}500{,}000{,}000{,}000} \approx 0.1214 \qquad 3.7$$

This translates to an instant 12.1% drop in overall Eurozone retail deposits. A trillion-euro drain exposes fatal vulnerability across the European commercial banking sector. The giants of the European financial institutions (BNP Paribas, Intesa Sanpaolo, …) consistently hold enough High-Quality Liquid Assets (HQLA) to survive such disastrous event, but it does not mean they are unaffected. A sudden 12.1% loss is still a massive hit to these Tier-1 commercial banks as it severely crushes their liquidity buffers, damages its stock valuations, and forces them into defensive restructuring.

As for small and medium sized commercial banks, that exact same 12.1% drain is unsustainable for them. As the Moderate Shift scenario showed that a 6% loss pushes these institutions to their absolute operational limit, doubling that pressure to a 12.1% sudden drop would completely shatter their financial foundation as it wipes out their collateral instantly. Smaller regional banks just simply cannot survive a double-digit percentage loss of their retail deposits overnight, as they lack structure reserves and liquidity buffers unlike the Tier-1 commercial banks. Therefore, a 12.1% shock would

push them straight into immediate insolvency and forced liquidation. A €3,000 holding limit does not guarantee survival for everyone and it will not save every vulnerable small bank during a blind panic. Yet it serves as the ultimate regulatory limit by mathematically stopping the systemic drain at exactly 12.1%. It isolates the damage and stops local bankruptcies from causing a total Eurozone financial meltdown.

CONCLUSION:

The main question that guided this research was whether the proposed €3,000 holding limit is enough to protect the financial stability of the Eurozone and prevent a "digital bank run". Introducing this risk-free, frictionless Central Bank Digital Currency (CBDC) and how it permanently alters the speed of bank runs. Without traditional cash withdrawals, commercial banks face the threat of instant transfers of savings into central bank liabilities with a simple tap on a smartphone.

To answer this mathematically, this research stress-tested the commercial banking sector using a baseline of 344 million eligible citizens and €8.5 trillion in total retail deposits. The empirical simulations proved that a digital run guarantees highly unequal survival. In a routine scenario with an average of €500 digital wallet balance, the resulting 2.0% deposit drop poses zero operational risk to any institution. Pushing that balance to a €1,500 moderate shift exposes the first critical fracture. A 6.1% drop is easily absorbed by the massive liquidity buffers of Tier-1 commercial banks like BNP Paribas and Intesa Sanpaolo. However, for small and medium sized regional banks, a 6% drop is their absolute limit as they start to face real pressure and it forces them to hunt for expensive wholesale funding just to stay balanced, and it hurts their profit margins and sits them close to operational distress. They survive only because they can still pledge their remaining eligible assets to the central bank in exchange for emergency cash.

The Systemic Panic delivers the final factual proof. If the entire European population maxes out their digital wallets at the same time, the total liquidity outflow will reach approximately €1.032 trillion. This translates to an instant 12.1% systemic drain. While Tier-1 institutions possess enough High-Quality Liquid Assets to survive this double-

digit shock. However, it severely crushes their liquidity buffers, damage its stock valuations, and forces them into defensive restructuring. This exact same drain acts as a definitive death sentence for smaller commercial banks. It instantly vaporizes their remaining collateral, forcing them into immediate insolvency. Ultimately, the mathematics proves that the €3,000 limit is a non-negotiable regulatory necessity. It does not guarantee universal survival. It will not save every vulnerable small bank during a blind panic. Yet, it serves as the ultimate macroeconomic circuit breaker. When stopping this systemic drain at 12.1% mathematically, the limit prevents localized stress from causing a hazard in the European financial system.

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