

TARGET2 Imbalances as a Settlement Substitute: Interbank Market Fragmentation and Financial Stress in the Euro Area

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Abstract

This paper examines TARGET2 imbalances in relation to the slowdown of the euro area overnight interbank market and the transformation of the Eurosystem's operational framework after the global financial crisis and the European sovereign debt crisis. It argues that TARGET2 imbalances are not merely technical by-products of Eurosystem balance-sheet expansion, but balance-sheet traces of a structural reorganization of liquidity circulation inside the euro area. The paper develops and tests a substitution hypothesis: when private cross-border redistribution of central-bank liquidity through the overnight interbank market weakens, public settlement through TARGET2 increasingly records liquidity flows no longer intermediated through private money markets. Using a vector autoregressive framework for the euro area, the analysis links TARGET2 dynamics to overnight interbank market activity, the overnight money-market rate, and the Composite Indicator of Systemic Stress. The results show that positive shocks to TARGET2 imbalances generate a significant and persistent contraction in overnight interbank transaction volume, while financial-stress shocks generate an immediate and durable increase in TARGET2 imbalances. A complementary transmission analysis further shows that TARGET2 is the most persistent balance-sheet response to excess-liquidity shocks among the variables considered, exhibiting a larger and more durable response than sovereign bond yields, equity prices, or bank lending. Finally, regime-threshold results suggest that the center-periphery confidence gap becomes statistically relevant for TARGET2 accumulation only in the abundant-reserves regime, linking settlement dynamics to safe-asset scarcity and incomplete financial integration. The findings imply that TARGET2 should be interpreted not only as an accounting counterpart of central-bank operations, but also as a signal of impaired private liquidity circulation, financial fragmentation, and the evolving operational architecture of the Eurosystem.

Keywords: TARGET2 imbalances; settlement infrastructure; euro area interbank market; excess liquidity; financial fragmentation; financial stress; monetary policy implementation

JEL codes: E42, E44, E52, E58, F36

¹ The paper draws on the author's doctoral dissertation, *Monetary policy and TARGET2 Imbalances within the Eurosystem*, defended at the Faculty of Economics and Business, University of Zagreb.

1. INTRODUCTION

The global financial crisis of 2007–2009 and the subsequent European sovereign debt crisis of 2010–2012 produced what may be described as a dual liquidity shock within the euro area: a simultaneous collapse of private interbank funding and an unprecedented expansion of central-bank balance sheets (Borio and Disyatat, 2009; Borio, 2023). Among the most visible and analytically contested by-products of this dual shock was the accumulation of large and persistent TARGET2 imbalances, net claims and liabilities recorded on the balance sheets of Eurosystem national central banks (NCBs), reflecting the net cross-border circulation of central-bank reserves within the monetary union. From near-zero before 2007, aggregate absolute TARGET2 imbalances grew to exceed one trillion euros by 2012, and reached approximately €1.9 trillion following the Pandemic Emergency Purchase Programme.

The dominant interpretation in official accounts, advanced by the ECB (2016, 2017) and the Bundesbank (2016), frames TARGET2 imbalances primarily as technical by-products of quantitative easing: because asset purchases are executed through decentralized national central banks but reserves created in one jurisdiction tend to flow to financial centers in others, imbalances arise automatically. Under this view, TARGET2 is essentially a passive ledger, and its dynamics are explained primarily by the geography of asset markets and the scale of balance-sheet expansion. This interpretation is analytically coherent, but it risks understating the information content of TARGET2 dynamics for the assessment of money-market functioning and financial integration within the monetary union.

This paper qualifies this interpretation in two ways. First, it advances a substitution hypothesis: TARGET2 imbalances are not merely a passive record of central-bank operations but a balance-sheet trace of structurally impaired private liquidity circulation. Before the crisis, cross-border reserve redistribution occurred predominantly through the overnight interbank market: banks with surplus reserves lent to deficit banks, bilateral positions cleared, and TARGET2 remained near zero. After the dual liquidity shock, this private channel fragmented (Frutos et al., 2016; Corradin et al., 2020). Banks in payment-deficit jurisdictions were forced to substitute central-bank refinancing for interbank borrowing, and the resulting unidirectional reserve flows accumulated as persistent TARGET2 imbalances. On this account, TARGET2 and the overnight interbank market are structural substitutes: when one contracts, the other expands. Second, the paper shows that financial stress constitutes an autonomous, non-monetary driver of TARGET2 dynamics, acting through flight-to-safety capital flows and

sudden stops in cross-border interbank lending independently of any specific central-bank policy decision.

The empirical analysis employs a vector autoregressive (VAR) framework for the euro area. The core findings are as follows. A positive shock to TARGET2 imbalances generates a significant negative cumulative response in overnight interbank market volume beginning around the fourth quarter, reaching its trough at quarters six to eight and remaining significant for up to three years — consistent with the substitution hypothesis. A positive shock to the CISS — the Composite Indicator of Systemic Stress — generates an immediate and persistent increase in TARGET2 imbalances, accounting for 12 per cent of their forecast-error variance at all horizons, consistent with the autonomous stress-driver hypothesis. A complementary transmission analysis, using the excess-liquidity-to-balance-sheet ratio as the monetary policy measure over the post-crisis sample, situates this mechanism within the broader landscape of QE-related balance-sheet transmission. It shows that TARGET2 emerges as the most persistent balance-sheet channel through which unconventional monetary policy is reflected in the euro area, exhibiting a larger and more durable response to excess-liquidity shocks than sovereign bond yields, equity prices, or bank lending. A threshold-regression exercise further shows that the center–periphery confidence gap becomes statistically relevant for TARGET2 accumulation only in the abundant-reserves regime: sovereign-risk divergence does not translate into persistent TARGET2 dynamics when liquidity is scarce and private interbank recycling is still operative, but becomes significant once public settlement has become the marginal redistribution channel. Together, these findings suggest that assessments of QE effectiveness focused on credit and asset-price channels may have underweighted the degree to which unconventional policy is absorbed by the settlement infrastructure of the monetary union itself.

These findings carry direct implications for the Eurosystem's operational framework and for the assessment of euro area financial integration. They suggest that the normalization of TARGET2 imbalances cannot be achieved merely through balance-sheet reduction; it requires the restoration of genuine cross-border private interbank activity. They imply that TARGET2 dynamics contain real-time information about the state of monetary union integration that is not subsumed by standard central-bank statistics. Finally, the finding that the center–periphery confidence gap becomes significantly associated with TARGET2 accumulation in the abundant-reserves regime suggests that persistent divergence in sovereign

credit quality is structurally relevant for the persistence of imbalances that monetary policy alone cannot resolve.

The remainder of the paper is structured as follows. Section 2 reviews the related literature. Section 3 develops the conceptual framework, including a stylized two-channel settlement representation. Section 4 discusses interbank market fragmentation and financial stress. Section 5 describes the data and empirical model. Section 6 presents the empirical results. Section 7 draws policy implications. Section 8 concludes.

2. RELATED LITERATURE

This section situates the paper within five strands of existing research before summarizing its contribution.

TARGET2 imbalances and capital-flow reversals. The foundational debate was opened by Sinn and Wollmershäuser (2012), who construct the first systematic database of TARGET2 imbalances and interpret them as a measure of covert balance-of-payments financing, creating contingent fiscal liabilities for creditor countries. This interpretation was contested on multiple grounds. Bindseil and König (2012) argued that TARGET2 imbalances reflect capital-flow reversals rather than current-account dynamics, attributing their growth to the collapse of private cross-border funding. Cecchetti, McCauley and McGuire (2012) similarly emphasized the role of private financial flows, while Whelan (2014) provided a systematic balance-sheet analysis demonstrating that TARGET2 liabilities carry fundamentally different risk characteristics from sovereign debt. Cesaratto (2013) places TARGET2 dynamics within the broader context of the euro area balance-of-payments crisis, arguing that imbalances reflect the systematic recycling of external deficits through the Eurosystem rather than through private capital markets. Sinn (2020) extends the original database and analysis to encompass the post-2012 period and the COVID-19 shock. Cecioni and Ferrero (2012) show empirically that the increase in TARGET2 liabilities of Italy, Spain and Portugal was driven overwhelmingly by the contraction of cross-border interbank and securities-market activity — a finding directly relevant to the substitution hypothesis developed here. Auer (2014) provides one of the most systematic panel-data analyses of TARGET2 drivers, showing that the post-2007 increase in TARGET2 balances reflected the sudden stop in private-sector capital flows that had previously financed current-account imbalances. The present paper extends this literature by focusing on the specific mechanism of interbank-market substitution and by identifying the

dynamic response structure through a time-series VAR framework applicable beyond the acute crisis period.

TARGET2 mechanics, excess liquidity and the balance-sheet interpretation. A second strand of literature examines the monetary mechanics and balance-sheet conditions under which TARGET2 imbalances accumulate. The most rigorous recent treatment is provided by Eisenschmidt, Kedan and Schmitz (2024), who establish excess liquidity as the necessary condition for TARGET2 accumulation and distinguish three phases of imbalance growth: a crisis phase driven by financial stress and capital flight (2007–2012), an APP phase driven by asset-purchase geography (2015–2019), and a post-pandemic phase. Their key conclusion is that financial market stress was the driver during 2007–2012, while Eurosystem asset purchases were the driving force from March 2015 onward. This account is closely related to official Eurosystem interpretations advanced by the ECB (2016, 2017) and the Bundesbank (2016), which emphasize the role of decentralized asset purchases and the geography of securities markets in explaining the post-2015 rise in TARGET2 balances. The present paper accepts the excess-liquidity necessary condition established by this literature, but argues that it is not sufficient to explain the directionality and persistence of TARGET2 dynamics. In particular, it examines whether financial stress retains independent explanatory power beyond the acute crisis phase and whether the private interbank market provides the missing redistribution channel through which excess liquidity is either privately recycled or publicly recorded through TARGET2. Hristov, Hülsewig and Wollmershäuser (2020) examine capital flows and TARGET2 using a panel VAR and find that financial integration shocks significantly affect TARGET2 dynamics. The present paper complements this approach by providing a time-series identification of the dynamic substitution mechanism between TARGET2 and overnight interbank activity.

Interbank market fragmentation and private liquidity recycling. A third strand of literature documents the fragmentation of euro area money markets after the global financial crisis and the sovereign debt crisis. Frutos et al. (2016) provide micro-level evidence of a severe contraction of cross-border unsecured interbank lending between core and periphery banks during 2011–2012, giving empirical substance to the fragmentation mechanism that this paper captures at the aggregate level. Al-Eyd and Berkmen (2013) examine money-market fragmentation and its implications for monetary policy transmission across euro area countries, finding that cross-country heterogeneity in the pass-through of ECB policy rates increased markedly during the sovereign debt crisis. Corradin et al. (2020) examine the interaction

between central-bank balance-sheet policy, money-market functioning and regulation, showing that excess reserve expansion fundamentally altered interbank market incentive structures. Altavilla et al. (2025) provide related micro-level evidence from the ECB's two-tier reserve remuneration system, showing that the distribution and reallocation of central-bank liquidity matter for money-market functioning and bank lending. These studies document the fragmentation and transformation of euro area money markets. The present paper extends this literature by estimating the dynamic relationship between interbank-market contraction and TARGET2 accumulation within a unified VAR framework. The argument is not simply that both TARGET2 imbalances and interbank volumes moved during the crisis, but that they represent alternative channels of cross-border reserve redistribution: when the private interbank channel weakens, public settlement through the Eurosystem balance sheet becomes more prominent.

Monetary policy implementation and monetary hierarchy. A fourth strand concerns monetary policy implementation under scarce and abundant reserves, and the monetary-theoretical distinction between bank money and central-bank money. Bindseil (2004) provides the foundational treatment of monetary policy implementation under the scarce-reserves corridor system, against which the post-crisis floor system must be understood. Borio and Disyatat (2009) develop the decoupling principle — the independence of balance-sheet and interest-rate policy under the floor system — which provides the theoretical foundation for the view that TARGET2 can accumulate independently of the short-term rate. Borio (2023) traces the operational consequences of the transition to abundant reserves. This operational literature is complemented by the monetary-theoretical literature on endogenous money, payment settlement and monetary hierarchy. Moore (1988), McLeay et al. (2014) and Lavoie (2022) provide the endogenous-money foundation for the view that bank credit and deposits are created within the banking system rather than intermediated from pre-existing reserves. Rossi (2007) and Mehrling (2013) provide the complementary payment-system and monetary-hierarchy perspective: central-bank money functions as the means of final settlement, while bank deposits occupy a lower hierarchical position as private monetary liabilities. Sheard (2013) states the same point in operational terms: central-bank reserves are the medium of final settlement, not loanable funds. This distinction is central to the substitution hypothesis. Cross-border payment flows may originate in private bank balance sheets, but their final settlement across national central banks occurs in central-bank money. TARGET2 imbalances therefore

record the settlement consequences of private balance-sheet decisions when these flows are not offset through private interbank recycling.

Financial stress, gross flows and safe-asset scarcity. A fifth strand provides the basis for interpreting TARGET2 dynamics as reflecting financial stress, gross capital flows and confidence-driven portfolio reallocation. Holló, Kremer and Lo Duca (2012) develop the Composite Indicator of Systemic Stress (CISS), the real-time euro area stress measure used in this paper. CISS is particularly appropriate for the present analysis because it aggregates stress across money markets, bond markets, equity markets, the banking sector and foreign exchange markets — precisely the conditions under which cross-border interbank lending and portfolio reallocations are likely to change. Borio and Disyatat (2015) argue that gross capital flows, driven by portfolio preferences, risk appetite and balance-sheet constraints, are the operative concept for understanding financial fragility. The present paper applies this logic to the euro area, where gross cross-border reserve flows respond to confidence dynamics rather than net trade positions. Caballero and Farhi (2017) provide a useful safe-asset-scarcity framework for interpreting the regime-dependent confidence effect. In an environment of scarce safe assets, a center–periphery confidence gap can become a persistent driver of portfolio reallocation. Under abundant reserves, such reallocations can translate directly into TARGET2 accumulation because public settlement becomes the marginal redistribution channel. This provides the theoretical basis for the threshold result reported later in the paper: sovereign-risk divergence becomes statistically relevant for TARGET2 accumulation only in the abundant-reserves regime.

Contribution. This paper makes four contributions. First, to the author’s knowledge, it is the first to identify a dynamic substitution relationship between TARGET2 accumulation and overnight interbank market contraction through impulse-response analysis, showing that the effect is persistent and bidirectional. Second, it provides evidence that financial stress has a persistent independent role in TARGET2 dynamics beyond the acute crisis phase, thereby qualifying phase-specific interpretations that treat stress primarily as a crisis-period driver. Third, it documents that TARGET2 emerges as the most persistent balance-sheet response to excess-liquidity shocks among the variables considered, suggesting that settlement infrastructure should be placed closer to the center of QE-related balance-sheet analysis. Fourth, it provides regime-threshold evidence that the center–periphery confidence gap becomes statistically relevant for TARGET2 accumulation only in the abundant-reserves

regime, linking TARGET2 dynamics to the broader institutional problem of safe-asset scarcity and incomplete financial integration within the euro area.

3. TARGET2 IMBALANCES IN THE ABUNDANT RESERVES REGIME: A CONCEPTUAL FRAMEWORK

3.1 From scarce to abundant reserves: the decoupling principle

The pre-crisis Eurosystem operated under a regime of structurally scarce reserves. The quantity of central-bank reserves was kept just sufficient to meet minimum reserve requirements, creating a chronic system-wide shortage that banks cleared daily on the overnight interbank market. The overnight unsecured interbank rate (EONIA) was the operational target of monetary policy, steered by the ECB to the midpoint of the interest-rate corridor through weekly main refinancing operations (MROs). This symmetric corridor system embodied a fundamental property of conventional monetary policy: it was conducted by setting the price of central-bank liquidity, not its quantity, with the quantity adjusting endogenously to banking-system demand at the prevailing rate (Bindseil, 2004; Borio, 2019; Borio, 2023).

The dual liquidity crisis transformed this architecture. Through fixed-rate full-allotment MROs (introduced October 2008), long-term refinancing operations of unprecedented scale and maturity, and ultimately large-scale asset purchase programmes, the Eurosystem injected surplus reserves far in excess of minimum requirements (ECB, 2008; Rostagno et al., 2021). The system transitioned from a corridor to a floor system: with excess reserves abundant, EONIA gravitated to the deposit facility rate floor rather than the corridor midpoint, and the link between reserve quantity and short-term rate was severed (Borio and Disyatat, 2009; Lavoie, 2022). As Figure 1 illustrates, this transition, visible from 2012 onward, was both abrupt and persistent.

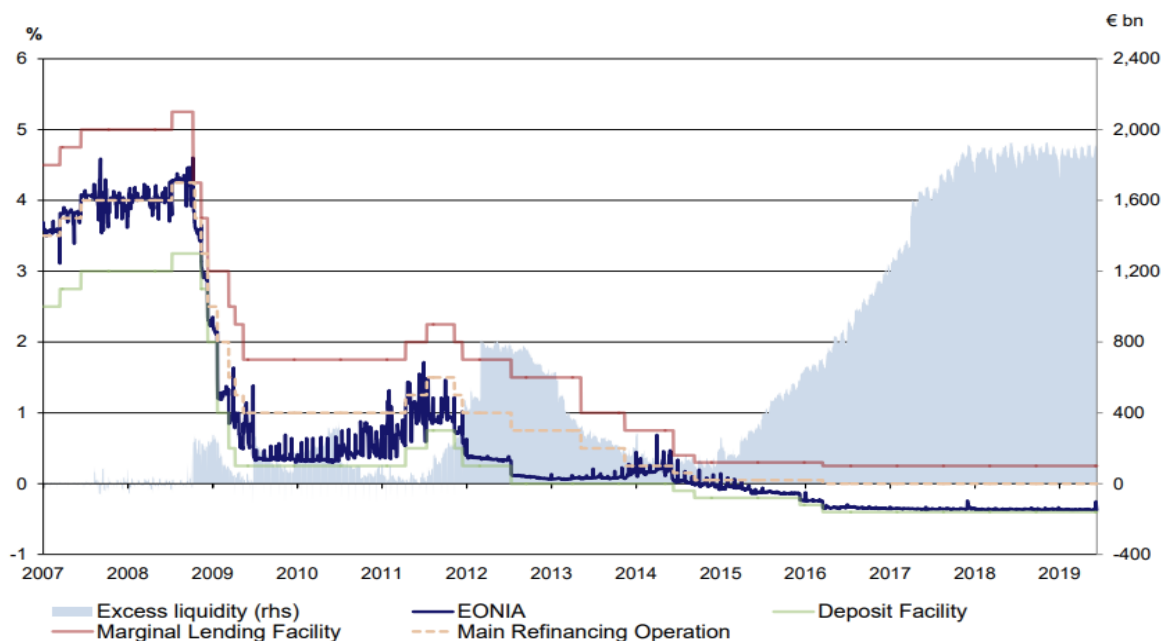


Figure 1. Eurosystem transition from corridor to floor: EONIA rate and excess liquidity, 2007–2019

Note: EONIA rate (solid line, left axis) and aggregate excess liquidity in EUR bn (shaded area, right axis).

Sources: ECB.

This transition — what Borio and Disyatat (2009) termed the decoupling principle — has a crucial implication for TARGET2: balance-sheet policy and interest-rate policy operate as independent instruments. TARGET2 imbalances can grow as central-bank reserves circulate unidirectionally cross-border, even while the short-term rate remains anchored at the floor. The endogenous money literature and central-bank balance-sheet perspective reinforce this point: central-bank reserves are the medium of final settlement, not loanable funds (Sheard, 2013; McLeay et al., 2014; Jakab and Kumhof, 2015; Rule, 2015; Lavoie, 2022). Persistent TARGET2 imbalances arise precisely when cross-border reserve flows generated by payment and investment transactions are not being offset by reverse flows — the case when private interbank recycling has broken down.

3.2 TARGET2 mechanics and the substitution hypothesis

TARGET2 provides real-time gross settlement in central-bank money across the Eurosystem.² In a stylized payment flow (an Italian bank transfers reserves to a German bank), the Banca d'Italia's net position vis-à-vis the Eurosystem deteriorates and the Bundesbank's

² A broader discussion of how this settlement infrastructure fits within the general hierarchy of central-bank and deposit-money payment systems is provided in Vujeva (2024), while Vujeva (2025) extends this argument to the role of structural excess liquidity.

improves by the same amount through the novation procedure (Murau and Giordano, 2022). Pre-crisis, this directional flow was quickly reversed: the Italian bank would borrow reserves in the overnight interbank market from a German surplus bank, and bilateral interbank positions would offset the initial settlement flow and prevent the accumulation of a persistent TARGET2 position. TARGET2 net positions reflected transient intraday flows, not persistent capital movements. In this sense, TARGET2 balances are net positions of national central banks, but their accumulation reflects the failure of gross cross-border payment and investment flows to be offset by reverse private financial flows.

After the interbank market fragmented, the equilibrating mechanism broke down. Unable to borrow from German banks, which had withdrawn from unsecured cross-border lending, Italian banks borrowed instead from the Banca d'Italia under FRFA MROs. The reserves thus created flowed to Germany in payment for Italian obligations, generating a TARGET2 liability for the Banca d'Italia and a TARGET2 claim for the Bundesbank. Crucially, this flow did not generate an offsetting interbank position: there was no private creditor to recycle the German surplus. The stock of imbalances accumulated. Eisenschmidt, Kedan and Schmitz (2024) formalize this accounting: structural excess liquidity is the necessary condition for sustained TARGET2 accumulation, since in a scarce-reserves system banks recycle surplus reserves through the market before imbalances can persist. The sufficient condition — the reason for the directionality and magnitude of accumulation — is the fragmentation of the private redistribution channel. This is the substitution hypothesis: TARGET2 substitutes for the overnight interbank market as the medium through which cross-border reserve redistribution occurs when the private channel is impaired.

3.3 A two-channel settlement representation

This section provides a stylized two-channel representation of the substitution hypothesis. Its purpose is not to provide a full structural model of bank optimization or general equilibrium. Rather, it formalizes the accounting logic behind the paper's empirical expectations: when private interbank recycling weakens, a larger part of cross-border reserve circulation is recorded through TARGET2 balances. While the accounting logic of TARGET2 accumulation under excess liquidity is formalized in Eisenschmidt et al. (2024), the present representation extends their framework by introducing the private recycling share θ^i as an explicit parameter, allowing the substitution mechanism, the financial stress channel, and the regime-dependent confidence effect to be derived as distinct testable propositions.

Setup. Consider a monetary union with two regions, core C and periphery P . Each region contains a national central bank and a representative bank. In each period, a directional cross-border settlement flow from banks in P to banks in C , denoted by $D_t > 0$, must be settled in central-bank reserves across different Eurosystem national central banks. The flow may arise from trade payments, debt service, capital reallocation, portfolio adjustment, or deposit transfers. The important point is that D_t is not a generic domestic payment flow: it is a net directional settlement pressure capable of altering the TARGET2 positions of the national central banks involved.³

Private interbank channel. The peripheral bank obtains reserves from the core bank through the overnight interbank market. The cross-border payment flow is thereby offset by a private interbank claim, so the directional settlement pressure does not translate into a persistent TARGET2 position.

Public settlement channel. The peripheral bank obtains reserves from the peripheral national central bank through refinancing operations. These reserves then flow through TARGET2 to the core national central bank, generating a TARGET2 liability for the peripheral national central bank and a TARGET2 claim for the core national central bank. In this case, the cross-border settlement flow is accommodated by the Eurosystem balance sheet rather than by a private interbank position.

Let $\theta_t \in [0,1]$ denote the share of the cross-border settlement flow D_t offset through private interbank recycling. Overnight interbank volume and TARGET2 accumulation are represented as:

$$VOL_t = \theta_t D_t \tag{1}$$

$$\Delta T2_t = (1 - \theta_t) D_t \tag{2}$$

where VOL_t denotes overnight interbank transaction volume and $\Delta T2_t$ denotes the change in aggregate TARGET2 imbalances. For a given D_t , equations (1) and (2) express the substitution mechanism: a lower private recycling share reduces interbank volume and increases the part of the directional settlement pressure recorded as TARGET2 accumulation.

³ Domestic payments within a single national central-bank jurisdiction are excluded from D_t . Although they may be settled in central-bank money, they alter the distribution of reserves within that jurisdiction rather than the net TARGET2 position of the corresponding national central bank.

The private recycling share is assumed to depend on systemic financial stress σ_t , excess liquidity E_t , and the center-periphery confidence gap γ_t . Define the abundant-reserves indicator as:

$$I_t = 1\{E_t > \bar{E}\} \quad (3)$$

The private recycling share is then specified as:

$$\theta_t = \bar{\theta} - \alpha\sigma_t - \beta E_t - \delta\gamma_t I_t, \quad \alpha, \beta, \delta > 0 \quad (4)$$

The linear specification should be interpreted as a local approximation around empirically relevant values, with θ_t bounded between zero and one. Here, $\bar{\theta}$ denotes the pre-crisis private recycling share and $\bar{E}$ is the threshold separating the scarce-reserves regime from the abundant-reserves regime. The interaction term $\gamma_t I_t$ captures the idea that confidence-driven portfolio shifts translate into persistent TARGET2 accumulation only when central-bank liquidity is sufficiently abundant for public settlement to become the marginal redistribution channel.

Substituting equation (4) into equation (2) gives the core expression:

$$\Delta T2_t = [1 - \bar{\theta} + \alpha\sigma_t + \beta E_t + \delta\gamma_t I_t] D_t \quad (5)$$

Equation (5) makes the comparative statics transparent. TARGET2 accumulation increases with financial stress, excess liquidity, and — only in the abundant-reserves regime — the center-periphery confidence gap. The following comparative statics are conditional on a given directional settlement pressure D_t . This is appropriate for isolating the recycling mechanism, although in practice excess liquidity may also affect the gross scale of cross-border settlement flows themselves. This yields four empirical predictions.

Proposition 1: excess liquidity. An increase in excess liquidity raises TARGET2 accumulation:

$$\partial \Delta T2_t / \partial E_t = \beta D_t > 0 \quad (6)$$

This is the theoretical counterpart of the transmission analysis in Section 6.1.

Proposition 2: substitution. Private recycling and public settlement channels move as substitutes:

$$\partial VOL_t / \partial \theta_t = D_t > 0, \quad \partial \Delta T2_t / \partial \theta_t = -D_t < 0 \quad (7)$$

As θ_t declines, VOL_t falls and $\Delta T2_t$ rises. This corresponds to the expected negative response of interbank volume to a TARGET2 shock in Section 6.2. Empirically, this mechanism is not observed through θ_t directly, since θ_t is unobserved, but through the negative dynamic

relationship between changes in TARGET2 imbalances and changes in overnight interbank volume.

Proposition 3: financial stress. Financial stress reduces private recycling and raises TARGET2 accumulation:

$$\partial \Delta T2_t / \partial \sigma_t = \alpha D_t > 0 \quad (8)$$

This corresponds to the expected positive response of TARGET2 imbalances to a CISS shock in Section 6.3.

Proposition 4: confidence gap and regime-dependence. The confidence gap affects TARGET2 accumulation only in the abundant-reserves regime:

$$\begin{aligned} \partial \Delta T2_t / \partial \gamma_t &= 0, & \text{if } E_t \leq \bar{E} \\ \partial \Delta T2_t / \partial \gamma_t &= \delta D_t > 0, & \text{if } E_t > \bar{E} \end{aligned} \quad (9)$$

This corresponds to the threshold result reported in Section 7.3. The representation is intentionally non-structural. Its role is to provide a transparent theoretical prior for the sign and regime-dependence of the empirical relationships, not to reproduce the full dynamics of the Eurosystem. What follows is Section 4 that documents the empirical context in which this substitution operates: the structural collapse of euro area overnight interbank activity and the role of financial stress as an autonomous driver of liquidity circulation.

4. THE SLOWDOWN OF THE EURO AREA INTERBANK MARKET

4.1 Structural fragmentation and the collapse of EONIA volumes

The euro area overnight interbank market (measured by EONIA transaction volumes) performed a critical economic function in the pre-crisis era: it cleared the daily excess and deficit positions of all banks in the Eurosystem, redistributing reserves from surplus to deficit institutions at market rates. Before the crisis, the euro area overnight interbank market was sufficiently deep to perform the daily redistribution of reserve positions across banks; EONIA tracked the corridor midpoint closely; and cross-border lending between banks in different member states was economically significant, reflecting the high degree of wholesale money-market integration achieved in the years following the euro's introduction.

The global financial crisis triggered an abrupt collapse in unsecured interbank lending, most acutely after the Lehman Brothers failure in September 2008. Banks across the monetary

union curtailed cross-border lending as counterparty risk perceptions rose sharply and information asymmetries about balance-sheet exposures became prohibitive. The sovereign debt crisis compounded this fragmentation: Frutos et al. (2016) document that cross-border unsecured interbank lending between core and periphery euro area banks virtually ceased in the second half of 2011. The introduction of FRFA refinancing eliminated the urgency of market-based liquidity management: any bank with eligible collateral could obtain unlimited reserves from the NCB, rendering the interbank market redundant for liquidity management purposes. The subsequent adoption of negative deposit facility rates further altered interbank lending dynamics, as Heider, Saidi and Schepens (2019) show that life below zero creates incentives that run counter to the standard monetary policy transmission logic for bank intermediation. Figure 2 illustrates the resulting inverse co-movement: as TARGET2 imbalances grew, EONIA volumes declined sharply and persistently.

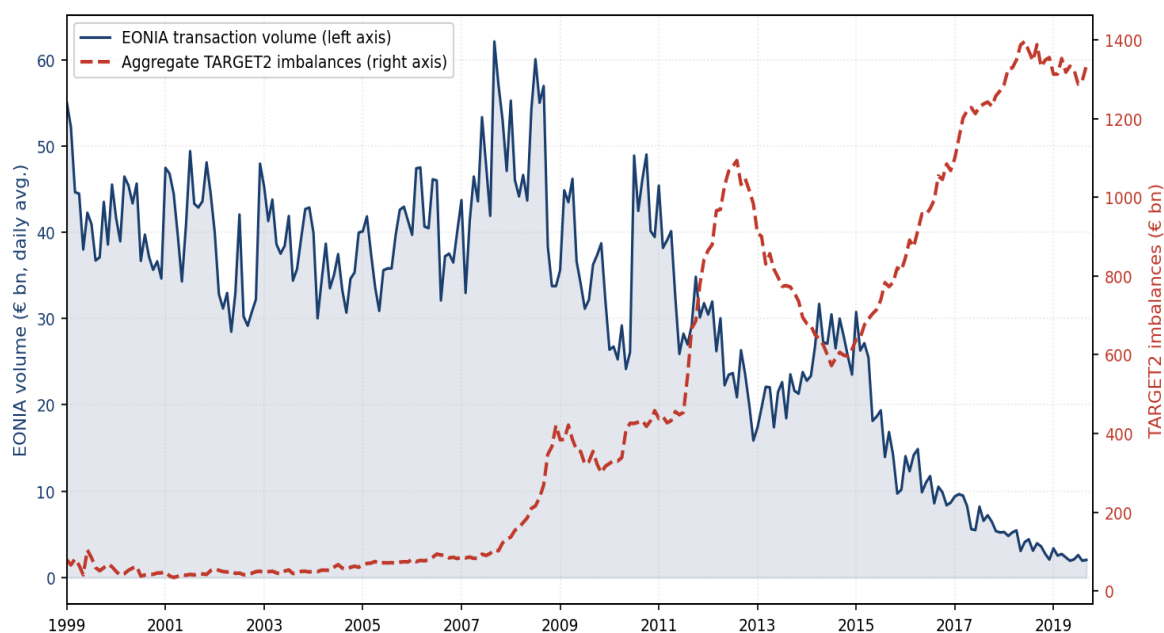


Figure 2. TARGET2 imbalances and EONIA transaction volume, 1999–2019

Note: Left axis shows EONIA daily average transaction volume in EUR bn (solid blue). Right axis shows aggregate absolute TARGET2 imbalances in EUR bn (dashed red). Monthly frequency. Sources: ECB Statistical Data Warehouse; Euro Crisis Monitor.

This inverse co-movement is not merely coincidental. It reflects the substitution mechanism: as the private redistribution channel contracted, the public settlement channel recorded the flows that private interbank lending was no longer recycling. After the most acute phase of the sovereign debt crisis passed in 2013–2014, EONIA volumes did not recover. The subsequent APP and TLTRO operations flooded the system with additional excess reserves,

further suppressing the incentive for active interbank liquidity management. By the end of the sample period in 2019, daily EONIA volumes had fallen to below €5 billion (a fraction of their pre-crisis levels), while TARGET2 imbalances remained elevated above €1 trillion.

4.2 Financial stress as an autonomous driver of liquidity circulation

The substitution of public for private redistribution is not an engineering outcome; it is a confidence outcome. Banks withdraw from cross-border unsecured lending not because of a policy decision but because of elevated counterparty risk, elevated information asymmetries, and declining trust in the fiscal credibility of sovereign backing for bank liabilities across jurisdictions. These forces operate independently of, though they interact with, the monetary policy stance.

The Composite Indicator of Systemic Stress (CISS), developed by Holló, Kremer and Lo Duca (2012), captures the contemporaneous level of instability in the euro area financial system as a whole, aggregating stress indicators from five market segments: the money market, the bond market, the equity market, the banking sector, and the foreign exchange market. CISS is a direct summary measure of the conditions under which banks make cross-border lending decisions. Its peaks at 2008 Q4 and 2011 Q3 coincide precisely with the two phases of most rapid TARGET2 accumulation (Figure 3), suggesting that financial stress generates TARGET2 dynamics beyond and above the mechanical effects of excess liquidity creation.

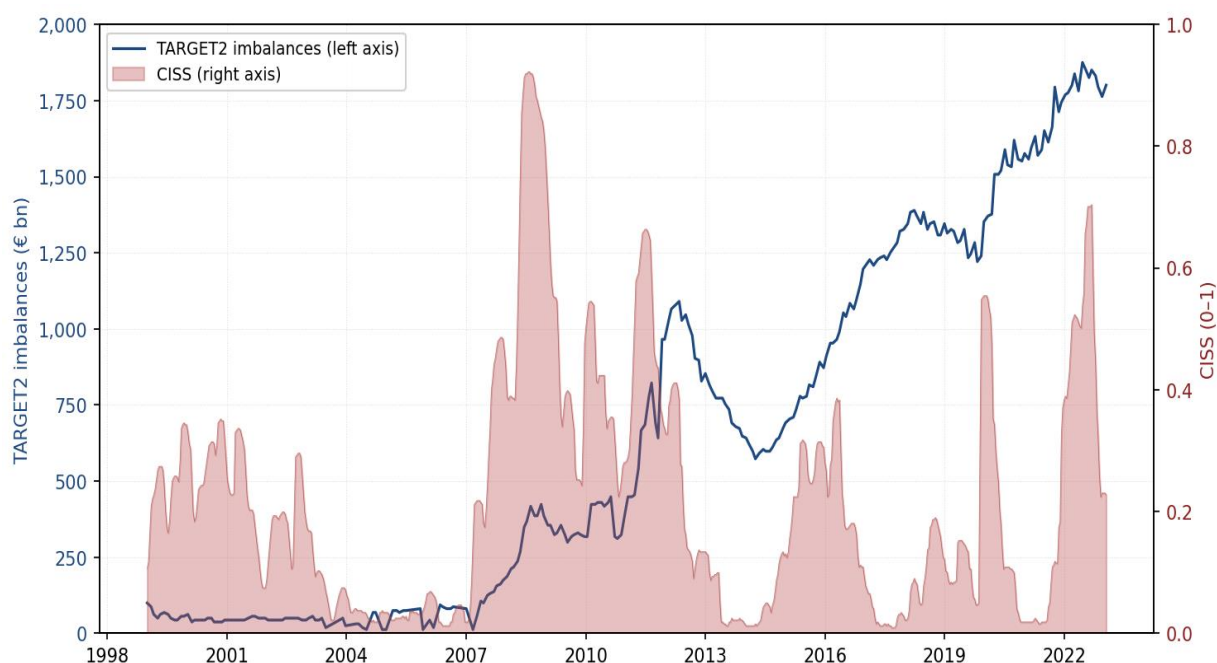


Figure 3. Aggregate TARGET2 imbalances and the CISS, 1999–2023

Note: Left axis shows aggregate absolute TARGET2 imbalances in EUR bn (solid blue). Right axis shows CISS (0–1; shaded). Sources: ECB Statistical Data Warehouse; Euro Crisis Monitor.

This non-monetary dimension of TARGET2 dynamics — stressed by Borio and Disyatat (2015) in their analysis of gross capital flows more broadly — implies that TARGET2 imbalances cannot be fully accounted for by the monetary policy stance alone, even after conditioning on the abundant reserves regime that is their necessary condition. Episodes of acute stress generate sudden stops in private cross-border lending and flight-to-safety portfolio reallocations from periphery to core, both of which translate into directional reserve flows that TARGET2 records as growing imbalances. To the extent that these stress dynamics are not captured by official monetary policy measures, they constitute an independent informational content of TARGET2 for financial integration assessment.

5. DATA AND EMPIRICAL STRATEGY

5.1 Variables and sample

The main analysis uses quarterly data for the euro area from 1999 Q2 to 2019 Q3 (82 observations), covering the full period from the inception of the euro through the end of published EONIA transaction volume data. This sample spans both the pre-crisis scarce-reserves regime and the post-crisis abundant-reserves regime, allowing the structural shift to be identified within the model. The separate transmission analysis in Section 6.1 uses a different quarterly sample from 2008 Q2 to 2023 Q1, substituting the excess-liquidity-to-balance-sheet ratio (ELBE) for EONIA as the monetary policy measure.

The 2019 Q3 endpoint of the main model is determined by an institutional discontinuity rather than an analytical choice. EONIA, the overnight rate and the sole available measure of aggregate overnight unsecured interbank transaction volumes, was formally discontinued on 3 January 2022, but ECB publication of EONIA-linked transaction volume statistics ceased effectively with the €STR transition in October 2019, when EONIA was reduced to a mechanical spread over €STR. The VOL variable, the core observable for the substitution hypothesis, does not have a continuous, methodologically comparable counterpart after this date: the €STR is calculated from a broader and differently defined set of transactions that includes money market fund placements and incorporates market segments absent from the EONIA panel. This distinction matters because the substitution hypothesis concerns private interbank reserve recycling, whereas €STR captures a broader unsecured overnight money market that also includes transactions with non-bank financial institutions. A direct extension of the main model using €STR-based volume data after 2019 Q3 would therefore introduce a structural break in the measurement of the key dependent variable, potentially confounding genuine economic dynamics with changes in the transaction perimeter. The separate ELBE-based model in Section 6.1, which does not depend on interbank volume data and extends to 2023 Q1, provides the post-2019 evidence on TARGET2 and monetary policy transmission, and the robustness check using the restricted post-crisis sample (2007 Q2 – 2019 Q3) confirms that the substitution results hold specifically within the abundant-reserves period.⁴

⁴ Extending the substitution analysis to the COVID-19 and post-pandemic phases, exploiting granular €STR transaction data that would allow construction of a volume measure consistent with the pre-2019 EONIA panel, remains a valuable direction for future work.

The main system contains four variables. EONIA is the overnight unsecured interbank rate (percentage points), serving as the monetary policy proxy for the full sample period. CISS is the Composite Indicator of Systemic Stress (0–1 scale), sourced from the ECB Statistical Data Warehouse. T2 is the aggregate absolute TARGET2 imbalances (EUR bn), taken in natural logarithm, sourced from the Euro Crisis Monitor (University of Osnabrück). VOL is the daily average EONIA transaction volume (EUR bn), averaged to quarterly frequency and taken in natural logarithm, sourced from the ECB Statistical Data Warehouse. All variables are tested for stationarity via ADF tests (full results in the Appendix, Table A.1), found to be $I(1)$ in levels and $I(0)$ in first differences, and accordingly first-differenced prior to estimation. Although the ADF test for CISS marginally rejects the unit root hypothesis at the 5 per cent level under the constant-only specification ($p = 0.037$), the series fails to reject under the constant-and-trend specification ($p = 0.139$) and exhibits persistent dynamics consistent with near-integration. CISS is accordingly first-differenced to ensure a homogeneous treatment of all system variables and to avoid inference complications from mixing integration orders.⁵ Table 1 summarizes all variables used across the empirical analysis. Tables 2 and 3 restrict attention to the four variables entering the main substitution VAR — EONIA, CISS, T2 and VOL — because the supplementary transmission variables are used in a separate post-crisis specification with a different sample period. Table 2 reports summary statistics for the main VAR variables in levels, and Table 3 reports the corresponding correlation matrix. The strong negative correlation between $\ln(T2)$ and $\ln(VOL)$ of -0.713 provides preliminary descriptive support for the substitution hypothesis. Notably, the modest level correlation between CISS and $\ln(T2)$ of 0.114 illustrates that the relationship between financial stress and TARGET2 accumulation is not visible in simple cross-sectional correlations — it is a dynamic relationship that emerges from the impulse response analysis.

The threshold analysis in Section 7.3 additionally employs two variables that capture the center–periphery dimension of euro area sovereign risk. YDIV is the GDP-weighted yield spread between southern TARGET2-deficit countries (Italy, Spain, Greece, Portugal) and core surplus countries (Germany, Netherlands, Luxembourg, Finland), constructed from 10-year sovereign yields and quarterly GDP weights. SAPD is the share of AAA-rated public debt in total euro area public debt, capturing the supply of euro-denominated safe assets. Both

⁵ All series are seasonally adjusted using the ARIMA X-12 method.

variables are tested for stationarity (Appendix Table A.1) and first-differenced prior to estimation. Their use is restricted to the threshold analysis, which extends through 2022 Q3.

Table 1. Summary of variables

Variable	Definition	Transformation	Source
EONIA	Euro overnight index average rate (%)	First difference	ECB SDW
CISS	Composite Indicator of Systemic Stress (0–1)	First difference	ECB SDW
T2	Aggregate absolute TARGET2 imbalances (bn EUR)	Log, first difference	Euro Crisis Monitor
VOL	Daily EONIA transaction volume (bn EUR)	Log, first difference	ECB SDW
ELBE	Excess liquidity / Eurosystem balance sheet (%)	First difference	ECB SDW
EA	Euro area sovereign bond yields	First difference	ECB SDW
EURSTX	Eurostoxx 50 equity index	Log, first difference	ECB SDW
LOANS	Bank loans to non-financial corporations	Log, first difference	ECB SDW
YDIV	GDP-weighted yield spread, southern deficit countries (IT, ES, GR, PT) minus core surplus countries (DE, NL, LU, FI)	First difference	ECB SDW, Eurostat
SAPD	Share of AAA-rated public debt in total euro area public debt (%)	First difference	ECB SDW, Eurostat

Note: ELBE, EA, EURSTX and LOANS are used in the supplementary transmission analysis (Section 6.1), sample 2008 Q2–2023 Q1. ELBE denotes the excess-liquidity-to-Eurosystem-balance-sheet ratio; EA denotes euro area sovereign bond yields; EURSTX denotes the Eurostoxx 50 equity index; and LOANS denotes bank loans to non-financial corporations. ELBE and EA enter the transmission VAR in first differences, while EURSTX and LOANS enter in log first differences. ELBE's level is used as the threshold variable in Section 7.3. YDIV and SAPD are used only in the threshold regression analysis (Section 7.3), sample 2000 Q2–2022 Q3.

Table 2. Descriptive statistics (quarterly levels, 1999 Q2 – 2019 Q3, n = 82)

Variable	Mean	Std. Dev.	Min	Max	Obs.
EONIA (%)	1.889	1.628	−0.360	4.900	82
CISS (0–1)	0.182	0.182	0.005	0.896	82
T2 (€ bn)	461.6	444.6	39.8	1,376.9	82
VOL (€ bn, daily avg.)	30.8	13.9	2.1	57.3	82
ln(T2)	5.455	1.284	3.685	7.228	82
ln(VOL)	3.235	0.757	0.755	4.049	82

Note: T2 = aggregate absolute TARGET2 imbalances. VOL = daily average EONIA-eligible overnight interbank transaction volume. All series at quarterly frequency, seasonally adjusted. Sources: ECB Statistical Data Warehouse; Euro Crisis Monitor (University of Osnabrück).

Table 3. Correlation matrix (quarterly levels, 1999 Q2 – 2019 Q3)

	EONIA	CISS	ln(T2)	ln(VOL)
EONIA	1.000	—	—	—
CISS	0.353	1.000	—	—
ln(T2)	−0.779	0.114	1.000	—
ln(VOL)	0.701	0.240	−0.713	1.000

Note: Pearson correlation coefficients. The strong negative correlation between ln(T2) and ln(VOL) provides preliminary descriptive support for the substitution hypothesis. The low level correlation between CISS and ln(T2) reflects the dynamic rather than contemporaneous nature of the stress–TARGET2 relationship.

5.2 VAR specification and identification

The main empirical model is a four-variable VAR (Sims, 1980) estimated for $[\Delta\text{EONIA}, \Delta\text{CISS}, \Delta\text{lnT2}, \Delta\text{lnVOL}]$. The lag order of four quarters is selected by AIC, BIC,

and HQC criteria (see Lütkepohl, 2011, for the general framework). The system is estimated as a subset VAR using Sequential Elimination of Regressors (SER; Brüggemann and Lütkepohl, 2001) at a 10 per cent significance threshold, yielding a parsimonious specification without sacrificing dynamic completeness.⁶ The SER procedure addresses this directly by eliminating statistically redundant lag coefficients while preserving all economically significant dynamic linkages, making it particularly well-suited to moderate-length samples of this kind. Where necessary, additive outlier dummies are included to account for the major structural breaks in the sample period.

Structural identification uses the recursive Cholesky decomposition with the ordering $EONIA \rightarrow CISS \rightarrow T2 \rightarrow VOL$. The ordering is motivated by the institutional logic of monetary union settlement. EONIA is ordered first as the contemporaneously predetermined policy instrument: the ECB sets the corridor and steers EONIA via operational decisions taken in advance of the quarter's realized money-market and TARGET2 dynamics. CISS is ordered second on the assumption that systemic stress conditions are determined by financial market dynamics that precede, within the quarter, the institutional reallocation of settlement flows between private and public channels. The CISS aggregates information from the money market, bond market, equity market, banking sector, and foreign exchange market, providing a within-quarter control for sovereign risk and counterparty-risk sentiment that might otherwise be picked up by the T2 or VOL shocks. T2 is ordered before VOL: at quarterly frequency, the relevant ordering question is whether accumulated TARGET2 positions condition private interbank activity in the same quarter, or vice versa. The substitution mechanism developed in Section 3 implies the former — payment-deficit banks resort to TARGET2 settlement when private channels fail, and the stock of accumulated imbalances signals to market participants the state of the private redistribution channel. Daily within-quarter feedback in the reverse direction is unavoidable in principle, but the recursive restriction asks only that the *net* contemporaneous effect of VOL changes on T2 changes — after CISS has been controlled for — be approximately zero.

Two considerations support the identifying assumptions. First, the inclusion of CISS before T2 and VOL absorbs the principal source of common contemporaneous variation — generalized financial stress — and residual orthogonality tests confirm that the estimated structural shocks are uncorrelated. Second, the qualitative results are robust to alternative

⁶ With 82 quarterly observations and four lags of four variables, full VAR estimation would consume 64 degrees of freedom in regressors alone, leaving limited residual degrees of freedom for inference.

orderings, including the reverse ordering $VOL \rightarrow T2 \rightarrow CISS \rightarrow EONIA$ reported in Section 6.4: the sign and significance of the substitution response and of the stress response in T2 are preserved. Point magnitudes may nonetheless be subject to ordering-related distortion, and the impulse responses should be interpreted accordingly. The recursive identification chosen here is a defensible reduced-form structure given the available data; sharper identification via external instruments or sign restrictions remains a natural direction for further work.

6. EMPIRICAL RESULTS

6.1 TARGET2 as a persistent balance-sheet channel of unconventional monetary policy

Before examining the substitution mechanism and the role of financial stress, it is useful to establish where TARGET2 sits within the broader landscape of QE-related balance-sheet transmission. A substantial body of research has documented the effects of unconventional monetary policy through bond yields, equity prices, and credit (Gagnon et al., 2011; Blattner and Joyce, 2016). The present section shows that TARGET2 exceeds these channels in one critical dimension: persistence. A five-variable VAR estimated over the post-crisis sample 2008 Q2–2023 Q1 indicates that TARGET2 is the most durable balance-sheet response to excess-liquidity shocks among the variables considered, exhibiting a larger and longer-lasting response than sovereign bond yields, equity prices, or bank lending. This finding is not incidental: it implies that assessments of QE effectiveness focused on standard macroeconomic channels may have underweighted the degree to which balance-sheet policy is absorbed by the settlement infrastructure of the monetary union. This VAR replaces EONIA with ELBE — the excess-liquidity-to-balance-sheet ratio — as the monetary policy measure.⁷ ELBE is the ratio of EL to the total Eurosystem balance sheet, expressed as a percentage. This normalization by balance-sheet size ensures that ELBE captures the relative unconventionality of the monetary stance rather than its absolute scale, making it directly comparable across different phases of balance-sheet expansion. ELBE is a direct, quantity-based measure of the degree of unconventional accommodation, meaningful only in the abundant-reserves regime where the policy rate (EONIA) is floored at the deposit facility rate and conveys no marginal information

⁷ Excess liquidity (EL) is defined following ECB (2023) as: $EL = (\text{current-account holdings of euro area credit institutions} - \text{minimum reserve requirements}) + (\text{deposit facility utilization} - \text{marginal lending facility borrowing})$. This definition captures the net surplus of central-bank liquidity above the level required for reserve compliance: the first term measures reserves held beyond what is obligatory, and the second term nets out the deposit facility against any recourse to the marginal lending facility, reflecting the system-wide preference for holding rather than borrowing reserves.

about monetary conditions. The outcome variables are euro area sovereign bond yields (EA), the log of the Eurostoxx 50 equity index (EURSTX), and the log of bank loans to non-financial corporations (LOANS), alongside $\log(T2)$. The ordering places ELBE first, reflecting the view that the central-bank balance-sheet stance is predetermined with respect to the outcome variables within the quarter. Granger-causality tests provide additional support for treating ELBE as the leading policy variable in the transmission system.

The results, summarized in Table A.4 (Panel A) and visualized in Figure 4, indicate that TARGET2 is the most persistent of the balance-sheet responses considered. A one-standard-deviation shock to ELBE generates a response in TARGET2 that is positive, large, and shows no attenuation over a twenty-quarter horizon. By contrast, the response of sovereign bond yields is negative and fades after four to six quarters; the Eurostoxx response is statistically insignificant at most horizons; and the bank-lending response is weak and does not provide clear evidence of a strong credit-expansion channel in this specification. The persistence comparison is conducted in impulse-response space because IRFs measure how each variable responds to the same identified shock, holding the ordering structure fixed for all responders.

The variance decomposition in Table A.4 (Panel A) provides complementary information about the share of each variable’s own forecast-error variance attributable to ELBE shocks, but is not directly comparable across the four outcome variables: the recursive ordering places ELBE first and T2 second, which mechanically allows ELBE to affect T2 contemporaneously while restricting its contemporaneous effect on the lower-ordered variables. The variance decomposition is therefore reported for completeness, and the substantive comparison across channels rests on the impulse responses. Within T2 itself, ELBE shocks account for 13–16 per cent of forecast-error variance at all horizons beyond four quarters — a non-trivial share, but one that should not be interpreted as exceeding the contribution of the other channels in a structurally meaningful sense, given the ordering-dependence noted above.

Taken in impulse-response space, TARGET2 emerges as the most persistent balance-sheet channel through which unconventional monetary policy is reflected in the euro area among the variables considered — a result that suggests the “passive ledger” characterization is incomplete and that settlement infrastructure deserves a more central place in QE transmission analysis.

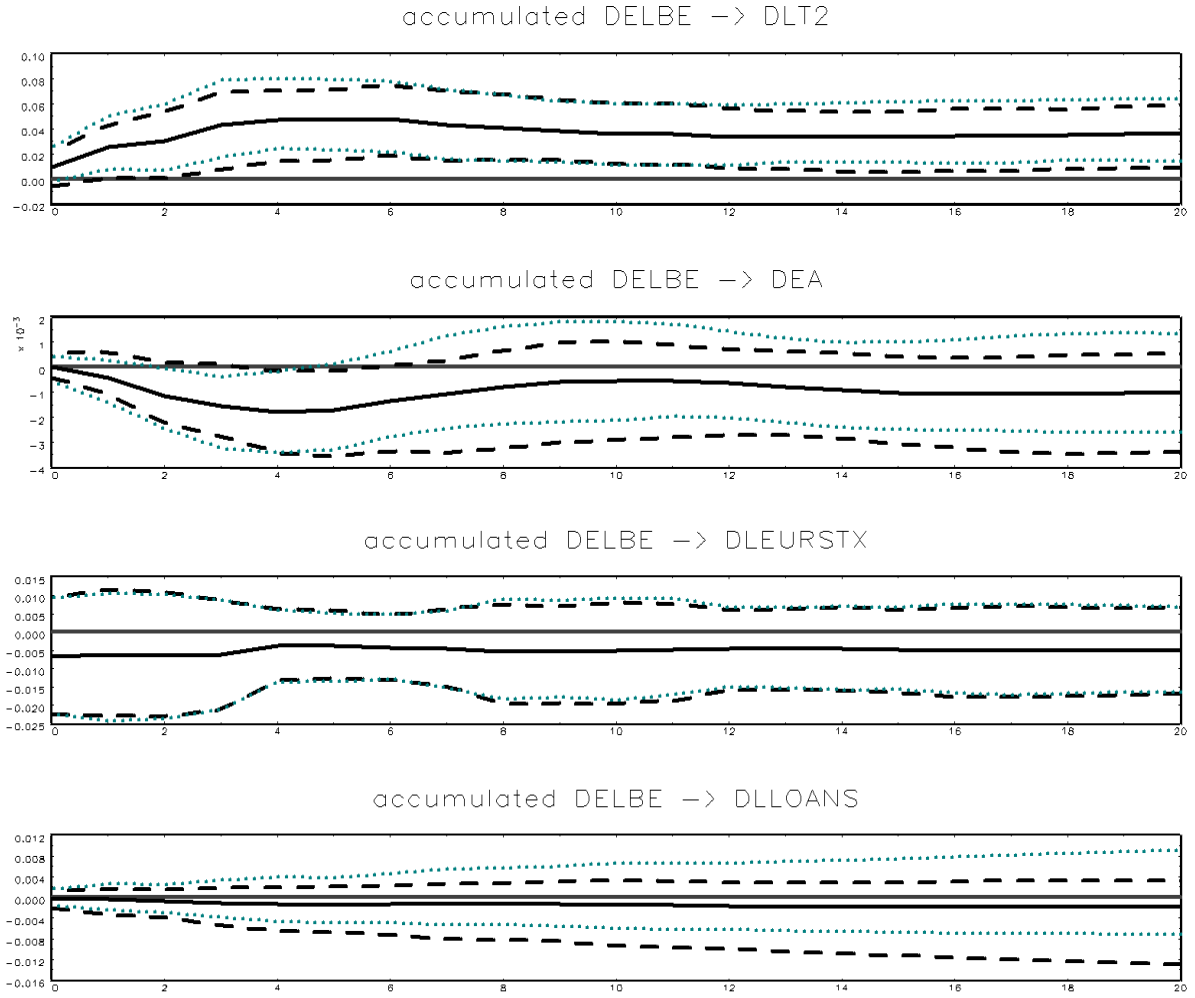


Figure 4. Impulse responses to an excess-liquidity (ELBE) shock across transmission channels

Note: Orthogonalized cumulative impulse responses of (top to bottom) $\Delta \ln T2$, $\Delta \text{bond yields}$, $\Delta \ln \text{Eurostoxx}$, $\Delta \ln \text{Loans}$ to a one-s.d. shock in ΔELBE . Solid: point estimate; dashed/dotted: 95% bootstrap confidence bands. Quarters on horizontal axis. Source: Author's estimates, JMulti.

The transmission analysis suggests that TARGET2 is not a passive by-product of central-bank operations, but the most persistent balance-sheet response to excess liquidity among the variables considered. This raises the question of mechanism: what drives the directionality and persistence of TARGET2 accumulation? Section 6.2 answers this through the substitution hypothesis.

6.2 The substitution mechanism: TARGET2 and interbank activity

Figure 5 displays the orthogonalized cumulative impulse response of $\Delta \ln \text{VOL}$ to a one-standard-deviation shock in $\Delta \ln T2$, with 95 per cent bootstrap confidence bands. A positive shock to TARGET2 imbalances — an unexpected increase in recorded net cross-border

settlement imbalances — induces a negative and statistically significant response in overnight interbank market volume. The effect is not contemporaneous: the point estimate remains near zero in the first two to three quarters following the shock, then turns negative and becomes statistically significant from the fourth quarter, reaching its trough between quarters six and eight. The cumulative response remains significantly negative through quarter twelve, with gradual attenuation thereafter.

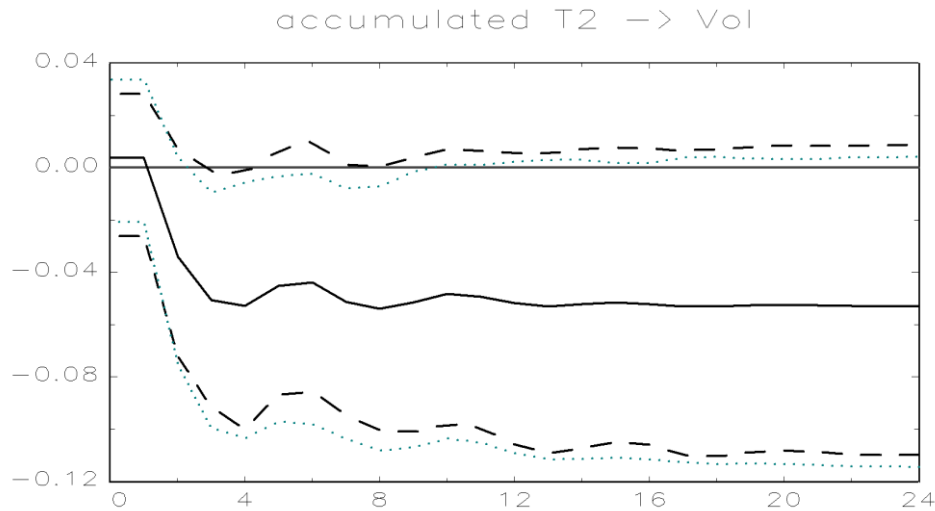


Figure 5. Impulse response of interbank volume to a TARGET2 imbalance shock

Note: Orthogonalized cumulative impulse response of $\Delta \ln \text{VOL}$ to a one-s.d. shock in $\Delta \ln \text{T2}$. Solid: point estimate; dashed/dotted: 95% bootstrap confidence bands (Efron–Hall). Source: Author's estimates, JMulTi.

The dynamics are strongly consistent with the substitution hypothesis. The delayed onset (rather than an immediate effect) reflects the structural nature of the substitution: TARGET2 accumulation does not instantaneously replace interbank activity but marks a persistent shift in the mode of liquidity redistribution that gradually erodes market activity over several quarters. As payment-deficit banks repeatedly source reserves from NCBs rather than from surplus-country interbank partners, the private overnight market loses depth and liquidity in a self-reinforcing process. The variance decomposition (Table A.4, Panel C) confirms bidirectionality: T2 shocks explain 9 per cent of VOL variance beyond 4 quarters, while VOL shocks explain 9 per cent of T2 variance: when private redistribution functions, TARGET2 accumulates less, and vice versa. This bidirectionality has a direct implication for normalization: because the two channels are mutually reinforcing, neither will restore itself automatically. The normalization of TARGET2 imbalances and the recovery of cross-border interbank activity are not sequential outcomes but interdependent processes: a reduction in

central-bank settlement without a recovery in private redistribution will not produce durable reintegration, and vice versa.

6.3 Financial stress and TARGET2 dynamics

Figure 6 displays the orthogonalized cumulative impulse response of $\Delta \ln T2$ to a one-standard-deviation shock in $\Delta CISS$. The response is positive, immediate, and statistically significant from the first quarter following the shock. TARGET2 imbalances react rapidly to increases in financial stress: the response is well above the upper confidence band at horizon one and remains significantly positive through at least eight quarters, consistent with the persistence of stress-induced fragmentation. The variance decomposition (Table A.4, Panel B) confirms that CISS shocks account for a stable 12 per cent of TARGET2 forecast-error variance at all horizons, a structural contribution that is neither transient nor confined to the crisis peaks.

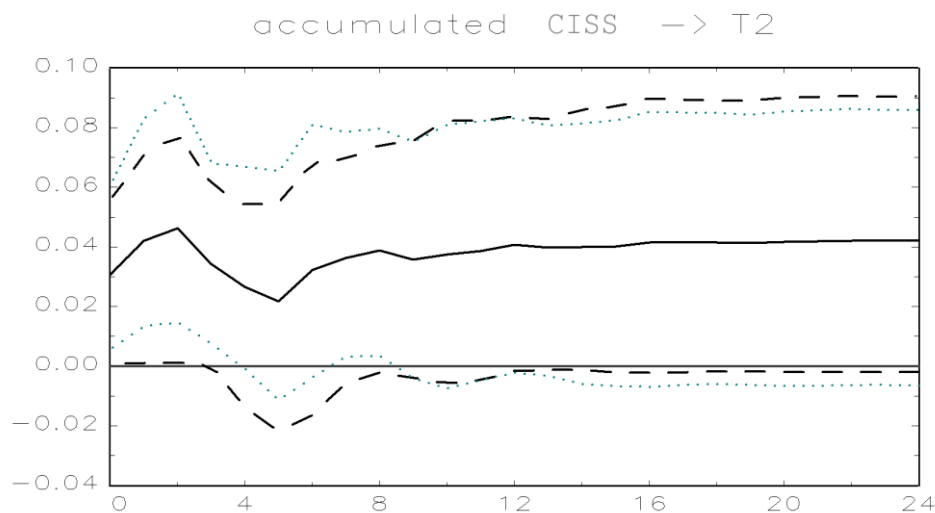


Figure 6. Impulse response of TARGET2 imbalances to a financial stress shock

Note: Orthogonalized cumulative impulse response of $\Delta \ln T2$ to a one-s.d. shock in $\Delta CISS$. Solid: point estimate; dashed/dotted: 95% bootstrap confidence bands (Efron–Hall). Source: Author's estimates, JMulTi.

This result suggests that the technical-by-product account is incomplete. In the main system, EONIA accounts for only 2 per cent of T2 forecast-error variance. This low share partly reflects the policy rate's reduced informativeness once it is anchored at the deposit facility floor for half the sample; the ELBE-based system in Section 6.1, which measures the unconventional stance directly, attributes 13–16 per cent of T2 variance to monetary policy shocks. The substantive contrast with the technical interpretation is therefore not that monetary

policy is unimportant. It is that the CISS retains an additional, independent share (12 per cent) of T2 variance even after controlling for the monetary stance. Even conditioning on the abundant-reserves regime (established by excess liquidity as the necessary background condition), financial stress retains independent explanatory power over TARGET2 dynamics. Taken together, the three sets of results — TARGET2 as the most persistent QE-related balance-sheet response, TARGET2 as a structural substitute for interbank redistribution, and financial stress as an autonomous non-monetary driver — provide mutually reinforcing evidence that TARGET2 is not an accounting residual, but an institutional register of the conditions under which the euro area’s private liquidity infrastructure operates.

6.4 Robustness

Post-crisis sample. The main VAR is re-estimated over 2007 Q2–2019 Q3, covering the crisis and post-crisis transition toward the abundant-reserves regime. The substitution response ($T2 \rightarrow VOL$) is somewhat stronger in this restricted sample: the trough occurs earlier (around quarter five) and the point estimates are larger, while the $CISS \rightarrow T2$ response is essentially unchanged. This confirms that the results are not artefacts of the full-sample transition from scarce to abundant reserves; they hold, and sharpen, within the crisis/post-crisis subsample. Figures 7 and 8 display the impulse responses for this restricted sample; Table A.3 reports the associated diagnostic tests, confirming validity of the alternative specification.

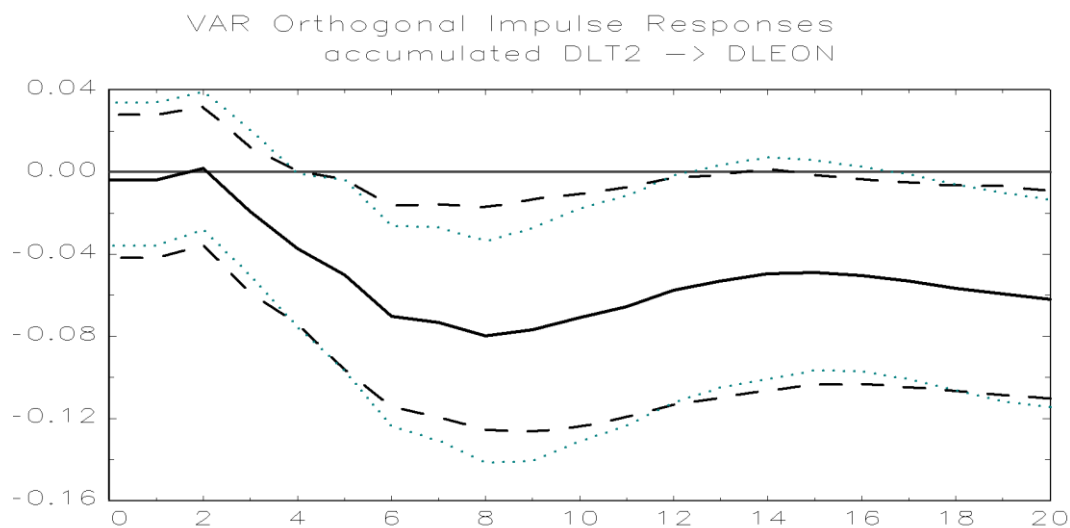


Figure 7. Robustness: impulse response of interbank volume to a TARGET2 shock (post-crisis sample, 2007 Q2 – 2019 Q3)

Note: Orthogonalized cumulative impulse response of $\Delta \ln VOL$ to a one-s.d. shock in $\Delta \ln T2$, subset VAR(4) estimated over the post-crisis abundant-reserves sample. Solid: point estimate; dashed/dotted: 95% bootstrap confidence bands. Horizon in quarters. Source: Author’s estimates, JMulTi.

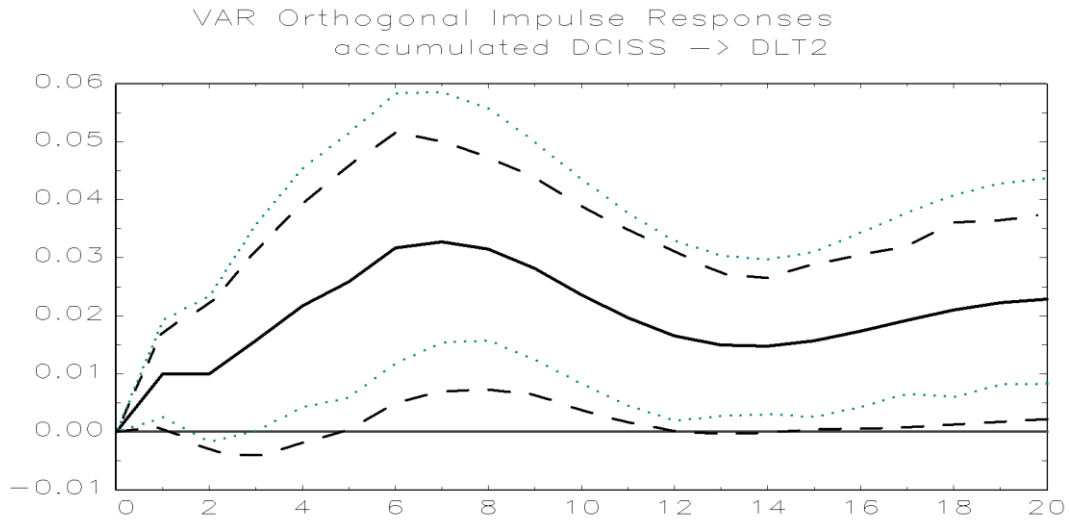


Figure 8. Robustness: impulse response of TARGET2 imbalances to a financial stress shock (post-crisis sample, 2007 Q2 – 2019 Q3)

Note: Orthogonalized cumulative impulse response of $\Delta \ln T2$ to a one-s.d. shock in $\Delta CISS$, subset VAR(4) estimated over the post-crisis abundant-reserves sample. Solid: point estimate; dashed/dotted: 95% bootstrap confidence bands. Horizon in quarters. Source: Author's estimates, JMulTi.

Alternative Cholesky ordering. Reversing the ordering to $VOL \rightarrow T2 \rightarrow CISS \rightarrow EONIA$ leaves the qualitative findings intact: the response of VOL to T2 shocks remains negative and significant at horizons four to eight, and the response of T2 to CISS shocks remains positive and significant.

7. IMPLICATIONS FOR THE EUROSISTEM'S OPERATIONAL FRAMEWORK

7.1 TARGET2 as a financial integration indicator

The most immediate implication of the results is interpretive. If TARGET2 imbalances carry independent information about the impairment of private cross-border liquidity redistribution, and the evidence presented here is that they do, then they should be read as indicators of financial integration rather than dismissed as accounting entries. Large, rising, or persistent imbalances signal that the monetary union is operating with a structurally weakened private liquidity-recycling infrastructure, relying on central-bank architecture to perform the redistribution function that integrated interbank markets would otherwise provide. This is qualitatively different from, and more policy-relevant than, the proposition that imbalances merely reflect the geography of asset purchases.

The informational content has operational value. TARGET2 dynamics, monitored alongside CISS and interbank market volumes, provide a real-time composite signal of the

degree of monetary-union financial integration that no single indicator captures alone. A rise in TARGET2 accompanied by rising CISS and falling EONIA volumes, the configuration observed during 2011–2012, indicates acute fragmentation requiring policy attention. A rise in TARGET2 accompanied by stable CISS and declining EONIA volumes, the configuration observed during the APP period 2015–2019, indicates a more structural, slower-moving impairment driven by the de-incentivization of market-based liquidity management. These two configurations call for different policy responses and cannot be distinguished by monitoring TARGET2 alone. The first, characterized by rising stress and collapsing interbank activity, calls for interventions that directly address counterparty risk and sovereign-bank contagion, as the OMT announcement demonstrated in 2012. The second, characterized by structural de-incentivization under abundant reserves, calls for reforms to the operational framework that restore the relative attractiveness of private interbank redistribution over central-bank settlement. Applying the instruments of the first configuration to the second risks treating a structural institutional problem as an acute confidence shock.

7.2 Balance-sheet normalization and the interbank market

The results bear directly on the Eurosystem's balance-sheet normalization strategy, which began with the reduction of APP reinvestments in 2023 and has since moved into a passive run-off phase following the final TLTRO III maturity and the end of PEPP reinvestments in December 2024. Normalization reduces excess liquidity, which is the necessary condition for TARGET2 accumulation. As the floor system shifts back toward a corridor (or corridor-like) system, there will be mechanical pressure for TARGET2 imbalances to decline. The ECB has acknowledged this in its March 2024 operational framework review (announced in December 2022 and concluded with formal decisions in March 2024) which contemplates a structural portfolio of eligible assets to prevent the system from tipping back to a full scarce-reserves regime.

The substitution hypothesis implies, however, that TARGET2 normalization should not be evaluated only by whether imbalances stop rising or decline mechanically with balance-sheet contraction. The more relevant question is whether their reduction is accompanied by a recovery of cross-border private interbank lending. If excess reserves decline but banks do not resume cross-border unsecured interbank lending (because structural fragmentation persists, safe-asset scarcity continues, or regulatory constraints on unsecured exposures remain binding), then TARGET2 imbalances may decline mechanically but remain structurally

elevated, reflecting the continued weakness of private liquidity recycling. The implication is that the ECB's balance-sheet normalization strategy requires a complementary assessment of interbank market recovery that goes beyond monitoring €STR rate levels.

The ECB's introduction of the two-tier reserve remuneration system in October 2019 (which exempted a multiple of required reserves from the negative deposit rate) was a step in this direction: by reducing the penalty on excess reserves, tiering created incentives for banks to recycle surplus reserves through the interbank market rather than park them at the deposit facility. Altavilla et al. (2025) find that tiering did increase bank lending at the margin. However, tiering operates at the price margin of reserve holding rather than at the structural level of cross-border interbank trust, and its effect on TARGET2 imbalances was correspondingly modest. The substitution hypothesis suggests that durable reintegration of the interbank market, and with it durable TARGET2 normalization, requires addressing the structural drivers of fragmentation, not merely the price incentives at the margin.⁸

7.3 The confidence gap under abundant reserves

A discrete threshold regression analysis, summarized in Table 4, provides a third dimension of policy relevance: the role of the center–periphery confidence gap. The purpose of this exercise is not to estimate the unique statistical breakpoint in TARGET2 dynamics, but to examine whether the confidence-gap relationship changes across economically meaningful monetary-operational regimes. The benchmark threshold is therefore theory-guided. The initial cutoff is set at approximately 2 per cent of the Eurosystem balance sheet, motivated by the distinction between transitory excess-liquidity fluctuations and a persistent abundant-reserves environment. The discrete threshold procedure then implements this cutoff at the closest admissible sample value, $ELBE = 0.0217$, corresponding to 2.17 per cent of the Eurosystem balance sheet. This separates the sample into a low-liquidity regime with 33 observations and an abundant-reserves regime with 57 observations. The confidence gap — measured by YDIV, the GDP-weighted yield spread between southern TARGET2-deficit countries (Italy, Spain, Greece, Portugal) and core surplus countries (Germany, Netherlands, Luxembourg, Finland)

⁸ A related cost dimension has been highlighted by Viljevac and Vujeva (2024), who document how the return to positive interest rates under the floor system generated substantial income transfers from the Eurosystem to commercial banks, a dynamic that reinforces the case for addressing the structural drivers of the abundant-reserves regime.

— captures the persistent divergence in sovereign credit quality that has characterized the euro area since the sovereign debt crisis.

The results reveal a sharp regime-dependence. In the low-liquidity regime, YDIV has no statistically significant effect on TARGET2 ($p = 0.637$): confidence gaps are present but they do not translate into persistent reserve flows when private interbank markets are functioning and T2 is near zero. In the abundant-reserves regime, YDIV has a positive and highly significant effect (coefficient = 0.065, $p = 0.001$): a widening of the center–periphery yield spread is associated with an acceleration of TARGET2 imbalance accumulation, even after controlling for the monetary policy stance and systemic stress. The abundant-reserves environment appears to transform a latent confidence gap into a statistically relevant correlate of reserve-flow directionality. At the same time, Δ CISS remains statistically significant in both regimes, reinforcing the earlier finding that systemic financial stress constitutes a regime-general driver of TARGET2 dynamics, whereas the confidence-gap channel is regime-specific to the abundant-reserves environment.

Table 4. Threshold regression model: TARGET2 imbalances and the confidence gap

Variable	Coefficient	Std. Error	t-stat	p-value
Regime 1: ELBE < 2.17% — low-liquidity regime (33 obs.)				
Δ YDIV	0.135	0.286	0.47	0.637
Δ CISS	0.777	0.263	2.96	0.004
Constant	0.04	0.018	2.28	0.026
Regime 2: ELBE $\geq$ 2.17% — abundant-reserves regime (57 obs.)				
Δ YDIV	0.065	0.019	3.35	0.001
Δ CISS	0.376	0.123	3.07	0.003
Constant	0.036	0.014	2.55	0.013

Note: Dependent variable: $\Delta \ln T2$. The ELBE threshold is theory-guided at approximately 2 per cent and implemented at the closest admissible sample value, $ELBE = 0.0217$, corresponding to 2.17 per cent of the Eurosystem balance sheet. Additional regime-specific controls (Δ EONIA, Δ SAPD) included but not shown; full estimates are reported in Appendix Table A.5. SAPD = share of safe assets (AAA-rated euro area public debt) in total euro area public debt. Sample: 2000 Q2 – 2022 Q3.

This finding connects to the safety-trap framework of Caballero and Farhi (2017). The sovereign downgrades of the 2010–2012 period reduced the supply of periphery safe assets and

created a structural preference for core-country collateral that monetary policy could alleviate but not eliminate. As long as this structural preference persists — as long as investors and banks in the periphery maintain portfolio preferences tilted toward core-country assets — the abundant-reserves environment may continue to channel such preferences into directional reserve flows, thereby limiting the full normalization of TARGET2 imbalances even when balance-sheet contraction mechanically reduces their level. The implications are institution-building rather than monetary: the resolution of persistent TARGET2 imbalances requires progress toward fiscal homogeneity, a common safe collateral framework — such as the European Safe Bonds (ESBies) proposed by Brunnermeier et al. (2016) to break the sovereign-bank diabolic loop — and genuine capital markets union — instruments that lie beyond the Eurosystem's conventional mandate but are highlighted by the empirical evidence.

As a robustness check, Table 5 reports an alternative threshold-regression specification in which EONIA serves as the threshold variable rather than ELBE. The alternative cutoff follows the same theory-guided logic: the initial threshold is set at approximately 2 per cent, corresponding to the operational distinction between the conventional corridor environment and the subsequent low-rate/floor-system environment. The discrete threshold procedure implements this cutoff at the closest admissible sample value, $EONIA = 2.002$ per cent.

The economic rationale is direct: EONIA falling below 2 per cent identifies the transition from the conventional corridor system — in which the policy rate was steered to the corridor midpoint — to the floor system in which EONIA gravitates to the deposit facility rate floor. This provides a fully independent operationalization of the same regime shift captured by the ELBE threshold in Table 4. The results are consistent. In the conventional-reserves regime ($EONIA \geq 2.002\%$), $\Delta YDIV$ is statistically insignificant (coefficient = 0.301, $p = 0.293$). In the floor system ($EONIA < 2.002\%$), $\Delta YDIV$ is positive and highly significant (coefficient = 0.057, $p = 0.006$). $\Delta CISS$ retains significance as a non-threshold variable. The qualitative conclusion is robust to the choice of threshold variable: the confidence gap becomes statistically relevant for TARGET2 accumulation specifically under abundant reserves, and not before.

Table 5. Robustness: EONIA-based threshold regression

Variable	Coefficient	Std. Error	t-stat	p-value
Regime 1: EONIA $\geq$ 2.002% — conventional reserves (35 obs.)				
$\Delta YDIV$	0.301	0.285	1.059	0.293
$\Delta ELBE$	1.849	1.315	1.406	0.164
$\Delta SAPD$	2.074	5.431	0.382	0.704
Constant	0.048	0.017	2.908	0.005
Regime 2: EONIA $<$ 2.002% — floor system/abundant reserves (55 obs.)				
$\Delta YDIV$	0.057	0.02	2.85	0.006
$\Delta ELBE$	0.418	0.368	1.134	0.26
$\Delta SAPD$	0.085	0.443	0.191	0.849
Constant	0.026	0.014	1.876	0.064
Non-Threshold Variable				
$\Delta CISS$	0.336	0.116	2.906	0.005

Note: Dependent variable: $\Delta \ln T2$. Threshold variable: EONIA. The EONIA threshold is theory-guided at approximately 2 per cent and implemented at the closest admissible sample value, EONIA = 2.002 per cent. $\Delta ELBE$ and $\Delta SAPD$ are allowed to vary by regime; $\Delta CISS$ is included as a non-threshold variable. SAPD = share of safe assets (AAA-rated euro area public debt) in total euro area public debt. Sample: 2000 Q2 – 2022 Q3.

7.4 Limitations and further research

The analysis is subject to four limitations. First, the aggregate euro area approach masks cross-country heterogeneity. Panel estimates distinguishing surplus from deficit countries would provide finer identification of the settlement-substitution mechanism. Second, the main substitution model ends in 2019 Q3 because of the discontinuity between EONIA and €STR transaction data. Extending the analysis through the PEPP period would test whether the mechanisms identified here operate similarly under a programme designed explicitly to prevent fragmentation. Third, the welfare implications of the structural shift from private liquidity recycling to public settlement remain open. Whether the automatic provision of central-bank settlement infrastructure during stress episodes is a stabilizing feature of the Eurosystem or an obstacle to market reintegration remains a question of first-order importance for the future operational framework. Fourth, the threshold exercise is intended as a theory-guided regime comparison rather than as a fully structural threshold identification. The exact cutoffs should

therefore be interpreted as operational approximations of regime transitions rather than as independently identified causal breakpoints.

8. CONCLUSION

This paper has argued that TARGET2 imbalances are not merely a technical by-product of quantitative easing but a balance-sheet trace of structurally impaired private liquidity circulation within the euro area monetary union. Three main empirical findings support this interpretation.

First, rising TARGET2 imbalances generate a significant, persistent negative response in overnight interbank market volume beginning around the fourth quarter after the shock and remaining significant for up to three years. TARGET2 and the overnight interbank market are structural substitutes: when private cross-border redistribution contracts, public central-bank settlement expands to fill the gap. The bidirectional variance decomposition (T2 shocks accounting for 9 per cent of VOL forecast-error variance and VOL shocks for 9 per cent of T2 variance at horizons beyond four quarters) implies that neither channel will restore itself automatically: durable normalization requires simultaneous recovery of both. Second, financial stress, measured by the CISS, constitutes an autonomous, non-monetary driver of TARGET2 dynamics, accounting for 12 per cent of forecast-error variance at all horizons independently of the monetary policy stance. TARGET2 contains real-time information about confidence and financial integration that is not subsumed by central-bank policy measures. Third, TARGET2 emerges as the most persistent balance-sheet channel through which unconventional monetary policy is reflected in the euro area: its response to an excess-liquidity shock is larger and more durable than those of sovereign bond yields, equity prices, or bank lending. This suggests that assessments of QE effectiveness focused on standard macroeconomic channels may have underweighted the degree to which balance-sheet policy is absorbed by the settlement infrastructure of the monetary union.

Taken together, these findings have three policy implications. For financial integration assessment, TARGET2 dynamics should be monitored as a composite indicator of private interbank market functioning alongside stress indicators, not treated as an inert accounting entry. For balance-sheet normalization, the ECB's exit from the abundant-reserves regime will reduce TARGET2 imbalances mechanically, but durable normalization requires the restoration of cross-border private interbank activity, which cannot be assumed to follow automatically from balance-sheet contraction. For the institutional architecture of the monetary union, the

finding that the center–periphery confidence gap becomes statistically relevant for TARGET2 accumulation in the abundant-reserves regime implies that the resolution of persistent imbalances requires institutional completions, such as a common safe asset, deeper capital markets union, and greater fiscal convergence, that all lie beyond monetary policy alone.

The central implication is that TARGET2 should be understood not only as a settlement ledger, but as an institutional trace of how liquidity circulation is reorganized when private cross-border interbank markets weaken. In a monetary union with centralized policy but decentralized balance sheets, persistent TARGET2 imbalances reveal more than the geography of central-bank operations. They reveal the extent to which public settlement infrastructure becomes central to preserving monetary continuity under conditions of private financial fragmentation.

REFERENCES

- Al-Eyd, A. and Berkmen, P. (2013). Fragmentation and monetary policy in the euro area. IMF Working Paper, No. 13/208.
- Altavilla, C., Boucinha, M., Burlon, L., Giannetti, M. and Schumacher, J. (2025). Central bank liquidity reallocation and bank lending: Evidence from the tiering system. *Journal of Financial Economics*, 168, Article 104058.
- Auer, R. (2014). What drives TARGET2 balances? Evidence from a panel analysis. *Economic Policy*, 29(77), 139-197.
- Bindseil, U. (2004). The operational target of monetary policy and the rise and fall of reserve position doctrine. ECB Working Paper Series, No. 372.
- Bindseil, U. and König, P. J. (2012). TARGET2 and the European sovereign debt crisis. *Credit and Capital Markets*, 45(2), 135–174.
- Blattner, T. and Joyce, M. (2016). Net debt supply shocks in the euro area and implications for QE. ECB Working Paper Series, No. 1957.
- Borio, C. (2019). On money, debt, trust and central banking. BIS Working Papers, No. 763.
- Borio, C. (2023). Getting up from the floor. BIS Working Papers, No. 1100.
- Borio, C. and Disyatat, P. (2009). Unconventional monetary policies: an appraisal. BIS Working Papers, No. 292.
- Borio, C. and Disyatat, P. (2015). Capital flows and the current account: taking financing (more) seriously. BIS Working Papers, No. 525.
- Brüggemann, R. and Lütkepohl, H. (2001). Lag selection in subset VAR models. In: *Econometric Studies: A Festschrift in Honour of Joachim Frohn*. LIT Verlag, Münster, 107–128.
- Brunnermeier, M. K., Garicano, L., Lane, P. R., Pagano, M., Reis, R., Santos, T., Thesmar, D., Van Nieuwerburgh, S. and Vayanos, D. (2016). The sovereign-bank diabolic loop and ESBies. *American Economic Review: Papers & Proceedings*, 106(5), 508–512.
- Bundesbank (2016). The impact of Eurosystem securities purchases on the TARGET2 balances. *Deutsche Bundesbank Monthly Report*, March.

- Caballero, R. and Farhi, E. (2017). The safety trap. *Review of Economic Studies*, 85(1), 223–274.
- Cecchetti, S. G., McCauley, R. N. and McGuire, P. M. (2012). Interpreting TARGET2 balances. BIS Working Papers, No. 393.
- Cecioni, M. and Ferrero, G. (2012). Determinants of TARGET2 imbalances. Bank of Italy Occasional Papers, No. 136.
- Cesaratto, S. (2013). The implications of TARGET2 in the European balance of payments crisis and beyond. *European Journal of Economics and Economic Policies: Intervention*, 10(3).
- Corradin, S., Eisenschmidt, J., Hoerova, M., Linzert, T., Schepens, G. and Sigaux, J.-D. (2020). Money markets, central bank balance sheet and regulation. ECB Working Paper Series, No. 2483.
- ECB (2008). Changes in tender procedure and in the standing facilities corridor. Press Release, 8 October. Available at: https://www.ecb.europa.eu/press/pr/date/2008/html/pr081008_2.en.html
- ECB (2016). TARGET balances and the asset purchase programme. *ECB Economic Bulletin*, No. 7/2016.
- ECB (2017). The ECB's asset purchase programme and TARGET balances. *ECB Economic Bulletin*, No. 3/2017.
- ECB (2023). Key ECB interest rates and excess liquidity. ECB Statistical Data Warehouse. Available at: <https://www.ecb.europa.eu/stats>
- Eisenschmidt, J., Kedan, D. and Schmitz, M. (2024). Euro area monetary policy and TARGET balances: A trilogy. *Journal of International Money and Finance*, 141, Article 103000.
- Euro Crisis Monitor (n.d.). University of Osnabrück. Available at: <https://www.eurocrisismonitor.com/> [Accessed: May 2026]
- Frutos, J. C., Garcia-de-Andoain, C., Heider, F. and Papsdorf, P. (2016). Stressed interbank markets: evidence from the European financial and sovereign debt crisis. ECB Working Paper Series, No. 1925.

- Gagnon, J., Raskin, M., Remache, J. and Sack, B. (2011). The financial market effects of the Federal Reserve's large-scale asset purchases. *International Journal of Central Banking*, 7(1), 3–43.
- Heider, F., Saidi, F. and Schepens, G. (2019). Life below zero: Bank lending under negative policy rates. *Review of Financial Studies*, 32(10), 3728–3761.
- Holló, D., Kremer, M. and Lo Duca, M. (2012). CISS — a composite indicator of systemic stress in the financial system. ECB Working Paper Series, No. 1426.
- Hristov, N., Hülsewig, O. and Wollmershäuser, T. (2020). Capital flows in the euro area and TARGET2 balances. *Journal of Banking & Finance*, 113, Article 105765.
- Jakab, Z. and Kumhof, M. (2015). Banks are not intermediaries of loanable funds — and why this matters. Bank of England Working Paper, No. 529.
- Lavoie, M. (2022). *Post-Keynesian Economics: New Foundations* (2nd ed.). Edward Elgar Publishing.
- Lütkepohl, H. (2011). Vector autoregressive models. EUI Working Papers, ECO 2011/30.
- MacKinnon, J. G. (1996). Numerical distribution functions for unit root and cointegration tests. *Journal of Applied Econometrics*, 11(6), 601–618.
- McLeay, M., Radia, A. and Thomas, R. (2014). Money creation in the modern economy. *Bank of England Quarterly Bulletin*, 54(1), 14–27.
- Mehrling, P. (2013). The inherent hierarchy of money. In: L. Taylor, A. Rezai and T. Michl (eds.), *Social Fairness and Economics: Economic Essays in the Spirit of Duncan Foley* (pp. 394–403). London and New York: Routledge.
- Moore, B. J. (1988). *Horizontalists and Verticalists: The Macroeconomics of Credit Money*. Cambridge: Cambridge University Press.
- Murau, S. and Giordano, M. (2022). European monetary unification through novation: the political economy of the TARGET system. Heinrich Böll Stiftung Berlin.
- Rossi, S. (2007). *Money and Payments in Theory and Practice*. London and New York: Routledge.

- Rostagno, M., Altavilla, C., Carboni, G., Lemke, W., Motto, R., Saint Guilhem, A. and Yiangou, J. (2021). *Monetary Policy in Times of Crisis: A Tale of Two Decades of the European Central Bank*. Oxford University Press.
- Rule, G. (2015). *Understanding the central bank balance sheet*. Bank of England, Centre for Central Banking Studies, Handbook No. 32.
- Sheard, P. (2013). Repeat after me: Banks cannot and do not lend out reserves. S&P Global Ratings, RatingsDirect.
- Sims, C. A. (1980). Macroeconomics and reality. *Econometrica*, 48(1), 1–48.
- Sinn, H. W. (2020). *The Economics of Target Balances: From Lehman to Corona*. Palgrave Macmillan.
- Sinn, H. W. and Wollmershäuser, T. (2012). TARGET loans, current account balances and capital flows: the ECB's rescue facility. *International Tax and Public Finance*, 19(4), 468-508.
- Viljevac, V. and Vujeva, K. (2024). Restrictive monetary policy and rising bank profitability: the case of Croatia after joining the euro area. *Proceedings of the 5th International Scientific Conference "The Economy of Decoupling"*. Croatian Academy of Sciences and Arts and Faculty of Economics and Business, University of Zagreb.
- Vujeva, K. (2024). *Monetary Policy and TARGET2 Imbalances within the Eurosystem*. Doctoral dissertation, Faculty of Economics and Business, University of Zagreb.
- Vujeva, K. (2025). The hierarchy and circulation of money within the euro area under conditions of structural excess liquidity. In: Učkar, D., Benazić, M. and Božina Beroš, M. (eds.), *Finance: From Classics to Digitalization*. Faculty of Economics and Tourism "Dr. Mijo Mirković", Pula.
- Whelan, K. (2014). TARGET2 and central bank balance sheets. *Economic Policy*, 29(77), 79–137.

Appendix. Additional Empirical Results and Diagnostics

Table A.1. ADF unit root tests (p-values)

Variable	Level — constant	Level — const. & trend	1st diff. — constant	1st diff. — const. & trend
EONIA	0.813	0.341	0.000	0.000
CISS	0.037	0.139	0.000	0.000
ln(T2)	0.732	0.104	0.001	0.005
ln(VOL)	0.599	0.075	0.000	0.000
ELBE	0.827	0.500	0.000	0.000
YDIV	0.075	0.214	0.000	0.000

Note: MacKinnon (1996) p-values. Lag length by AIC. All series treated as I(1) and first-differenced prior to estimation.

Table A.2. Diagnostic tests — main four-variable VAR system

Test	Statistic	p-value	Null hypothesis
LM test for autocorrelation (4 lags)	73.49	0.195	No serial correlation
Doornik–Hansen normality (joint)	6.16	0.629	Multivariate normality
ARCH-LM, EONIA equation	2.68	0.104	No ARCH effects
ARCH-LM, CISS equation	1.29	0.863	No ARCH effects
ARCH-LM, T2 equation	2.55	0.637	No ARCH effects

ARCH-LM, VOL equation	4.59	0.332	No ARCH effects
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Note: ARCH-LM uses 4 lags. All eigenvalues of the companion matrix lie outside the unit circle; the estimated VAR is stable.

Table A.3. Diagnostic tests – post-crisis sample VAR (2007 Q2 – 2019 Q3)

Test	Statistic	p-value	Null hypothesis
LM test for autocorrelation (4 lags)	77.71	0.117	No serial correlation
Doornik–Hansen normality (joint)	6.63	0.577	Multivariate normality
ARCH-LM, EONIA equation	3.60	0.463	No conditional heteroskedasticity
ARCH-LM, CISS equation	3.50	0.478	No conditional heteroskedasticity
ARCH-LM, T2 equation	2.71	0.608	No conditional heteroskedasticity
ARCH-LM, VOL equation	8.25	0.083	No conditional heteroskedasticity

Note: ARCH-LM tests use 4 lags. All eigenvalues of the companion matrix lie outside the unit circle; the estimated VAR is stable. Source: Author's estimates, JMulTi

Table A.4. Forecast-error variance decompositions

Horizon	$\Delta E L B E$	$\Delta \ln T2$	$\Delta E A$ yields	$\Delta \ln Eurostoxx$	$\Delta \ln Loans$
Panel A: Five-variable system — variance decomposition of $\Delta \ln T2$ (sample: 2008 Q2 – 2023 Q1)					
4 quarters	13	71	8	0	3
8 quarters	16	64	10	5	5
20 quarters	15	58	12	8	7
	$\Delta E O N I A$	$\Delta C I S S$	$\Delta \ln T2$	$\Delta \ln V O L$	
Panel B: Main four-variable system — variance decomposition of $\Delta \ln T2$					

(sample: 1999 Q2 – 2019 Q3)					
4 quarters	2	12	87	0	
8 quarters	2	12	77	9	
20 quarters	2	12	77	10	
Panel C: Main four-variable system — variance decomposition of $\Delta \ln \text{VOL}$					
4 quarters	2	2	9	87	
8 quarters	2	3	9	85	
20 quarters	2	3	9	85	

Note: Panel A from subset VAR(4), Cholesky ordering ELBE, T2, EA yields, Eurostoxx, Loans. Panels B–C from subset VAR(4), ordering EONIA, CISS, T2, VOL. Rows may not sum to 100 due to rounding.

Table A.5. Full threshold regression estimates with regime-specific controls

Variable	Coefficient	Std. Error	t-stat	p-value
Regime 1: ELBE < 2.17% — low-liquidity regime (33 obs.)				
ΔYDIV	0.135	0.286	0.47	0.637
ΔCISS	0.777	0.263	2.96	0.004
ΔEONIA	-0.073	0.066	-1.12	0.266
ΔSAPD	3.246	6.240	0.52	0.604

Constant	0.040	0.018	2.28	0.026
Regime 2: $ELBE \geq 2.17\%$ — abundant-reserves regime (57 obs.)				
$\Delta YDIV$	0.065	0.019	3.35	0.001
$\Delta CISS$	0.376	0.123	3.07	0.003
$\Delta EONIA$	-0.043	0.047	-0.93	0.356
$\Delta SAPD$	0.233	0.453	0.51	0.609
Constant	0.036	0.014	2.55	0.013