Implementation Models for Banks in the Context of the Digital Euro

A technical and organisational assessment of in-house, hybrid, and outsourced integration models

Rewritten and restructured thesis aligned with the provided research outline
January 2026

Abstract

The Eurosystem's digital euro project is progressing from investigation and preparation towards a potential implementation phase. For payment service providers (PSPs)—and especially banks—the decisive challenge is not conceptual alignment with a central bank digital currency (CBDC) but the practical integration into heterogeneous, regulated, and legacy-heavy payment stacks. This thesis develops a technical and organisational framework for integrating the Digital Euro into banks' existing systems. It analyses the Digital Euro Service Platform (DESP) and the digital euro scheme's rulebook work, identifies which bank modules are affected, and derives implementation models (in-house, hybrid, outsourced) across bank tiers. Particular emphasis is placed on mutualised integration (shared services) across PSPs, including not only software connectivity and compliance components but also physical acceptance infrastructure such as POS terminals, ATMs, and branch processes. Using published cost assessments (PwC cost study and the ECB's note on investment costs and synergy factors) and an additional scenario model, the thesis quantifies how shared integration can materially reduce implementation costs and delivery risks. The main contribution is an actionable reference architecture and decision matrix that links bank tier characteristics to recommended implementation models, together with a component-level map of what should be shared versus built and operated individually.

Keywords

Digital Euro; CBDC; banks; payment service providers; DESP; integration architecture; offline payments; implementation models; outsourcing; shared services; cost mutualisation; rulebook.

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1. Introduction

The digital euro project aims to provide a public, digital form of central bank money for the euro area. If issued, the digital euro would be distributed by supervised payment service providers (PSPs) such as banks, who would remain the primary customer interface. From a bank's perspective, the digital euro is therefore first and foremost an implementation problem: how to integrate a new scheme, interfaces, and operational processes into existing payment stacks while meeting strict requirements for resilience, security, privacy, and compliance.

The ECB's preparation work includes a draft scheme rulebook developed with market participants through the Rulebook Development Group (RDG), and the Digital Euro Service Platform (DESP) that provides common services and access gateways. The draft rulebook is expected to standardise services and interactions across PSPs, including access management, transaction management, liquidity management, dispute management, user experience, and brand rules (European Central Bank, 2025a; European Central Bank, 2025b).

While the original thesis (imp.pdf) already covered many technical aspects (e.g., DESP connectivity, conditional payments, offline concepts, and architectural patterns), it did not consistently follow the research outline's structure, and it under-emphasised (i) explicit mapping to the RDG rulebook structure, (ii) component-level analysis of what is shared versus institution-specific, and (iii) a tiered decision framework connecting bank types to implementation models. This rewritten thesis addresses those gaps while retaining the relevant technical content and expanding the cost and mutualisation analysis using ECB and PwC sources (PricewaterhouseCoopers, 2025; European Central Bank, 2025c).

1.1 Research focus and questions

The research is guided by the following focus points, derived from the provided research outline and the user's explicit research objectives:

- How banks can integrate the digital euro technically into existing systems (architecture, interfaces, security, operations).
- Which scheme services the ECB/Eurosystem provides (DESP, access gateway, scheme services) and what PSPs must implement.
- Which internal bank/PSP modules are affected (frontends, core banking, payments hub, AML/fraud, accounting, etc.).
- Which modules can be shared/mutualised across PSPs (software and hardware/acceptance infrastructure).
- Which modules must remain institution-specific (due to risk, data, governance, or competitive differentiation).
- How implementation models (in-house, hybrid, outsourced) vary by bank tier and by sourcing maturity.
- How mutualisation affects cost and time-to-market, including physical infrastructure such as POS and ATMs.

The corresponding research questions (RQs) are:

Table 1. Research questions

ID	Research question
RQ1	What are the main DESP and scheme interfaces and what integration patterns minimise change to bank cores?
RQ2	Which bank modules are impacted by digital euro requirements and how does impact vary by bank tier?
RQ3	Which components can be mutualised across PSPs (shared integration) and which should remain local?
RQ4	How do in-house, hybrid, and outsourced models compare in cost, control, risk, and delivery speed?
RQ5	Which implementation model is recommended for each bank tier given cost mutualisation potential and sourcing maturity?

1.2 Structure and alignment with the RDG rulebook

To ensure alignment with the scheme's evolving rulebook, the thesis is structured around a requirements-to-architecture flow: (i) scheme and rulebook context; (ii) DESP interfaces and technical integration; (iii) bank module impact; (iv) shared vs dedicated components; (v) implementation models by tier; and (vi) quantitative cost and synergy analysis. Where possible, terminology follows the RDG workstreams and the DESP experimentation artefacts (European Central Bank, 2025b; European Central Bank, 2025d).

2. Digital Euro scheme context and service offering

The digital euro is designed as a retail CBDC for the euro area, intended to complement cash and existing private digital payments. The project's design work has progressed through an investigation phase and a preparation phase, accompanied by legislative negotiations at EU level. Public communications from European institutions in late 2025 indicate ongoing policy alignment on the digital euro and the role of cash, with implementation timing dependent on legislation and operational readiness (Council of the European Union, 2025).

2.1 Roles and responsibilities

The scheme design follows a two-tier distribution model: the Eurosystem provides central infrastructure and rules, while PSPs distribute the digital euro to end-users. Under this model, PSPs are responsible for customer onboarding, customer support, compliance obligations (e.g., AML/KYC where applicable), and for integrating digital euro services into their channels and back-office processes (European Central Bank, 2025a; Euro Banking Association, 2023).

2.2 Scheme rulebook and RDG

A central artefact for implementation is the digital euro scheme rulebook. The closing report on the preparation phase describes the rulebook as a mechanism to standardise the scheme's functional and non-functional requirements, with content spanning access management, transaction management, liquidity management, dispute management, user experience, brand and scheme identity, and implementation specifications (European Central Bank, 2025a). The RDG progress reporting shows iterative refinement across workstreams and incorporation of market feedback, including a distinction between mandatory and optional provisions (European Central Bank, 2025b).

2.3 Digital Euro Service Platform (DESP)

From a technical standpoint, PSPs connect to the Eurosystem's Digital Euro Service Platform (DESP) via an access gateway. The DESP exposes services needed to operate the scheme (e.g., account/holding views, payment initiation and status, limits and waterfall logic, and other scheme services). In the DESP experimentation portal artefacts, the REST API is authenticated using BasicAuth (portal credentials), and a digital signature feature is provided for POST and PUT requests to ensure message authenticity and tamper resistance (European Central Bank, 2025d).

The experimentation portal highlights conditional payment flows using reservations and subsequent payments. For example, it supports the creation and retrieval of reservations and the creation of payments from a reservation. This reflects a direction of travel where conditional payments and value-added services can be enabled on top of the core digital euro payment rail (European Central Bank, 2025d).

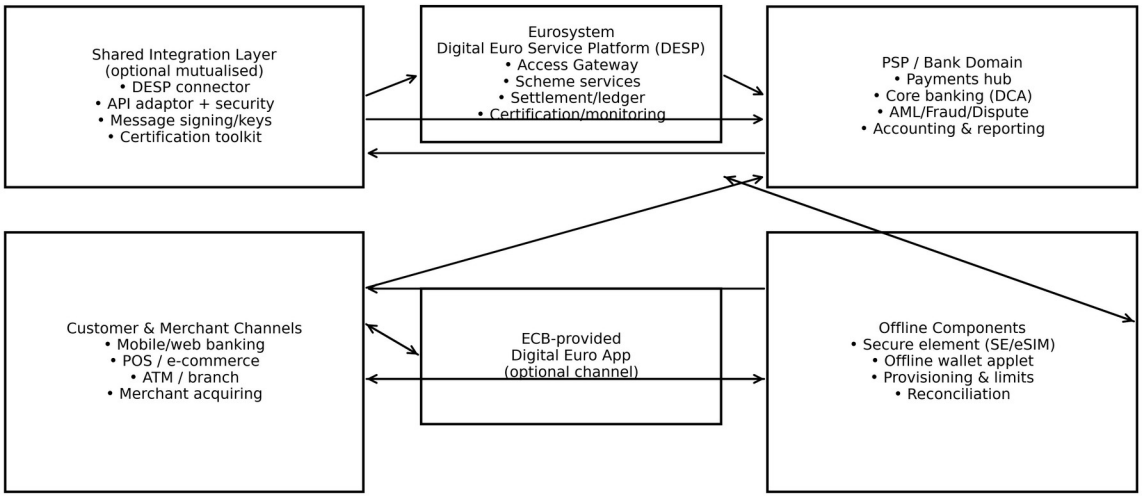

Figure 1. Reference integration landscape for DESP connectivity, shared services, channels, and offline components.

2.4 DESP service building blocks

The DESP is expected to provide common services that enable consistent scheme behaviour across all PSPs. In the experimentation portal user guide, an "Access Manager (PSP)" interacts with the "D€ Service Platform" via REST endpoints for holdings, reservations, and payments, indicating the building blocks required for wallet/holding views, payment initiation, and conditional payment primitives (European Central Bank, 2025d).

Table 2. Example DESP experimentation endpoints for conditional payments (illustrative)

Endpoint (illustrative)	Purpose
GET /holdings	Retrieve a list of holdings (wallet positions).
POST /reservations	Create a reservation for a conditional payment; returns a reservation response.
GET /reservations/{reservationId}	Retrieve reservation details.
POST /payments (reservationId)	Create a payment from a reservation; returns payment id and status.

2.5 Offline payments and acceptance infrastructure

Offline functionality is a key design requirement for a retail CBDC in the euro area, both for resilience and for cash-like usability. Offline payments typically rely on secure elements (e.g., secure hardware on a device, or protected applets) and require robust reconciliation processes when connectivity is restored. For banks, offline capability expands the implementation scope beyond software-only integration: acceptance infrastructure such as POS terminals and ATMs must support the digital euro scheme. The PwC digital euro cost study explicitly includes POS terminals, ATMs, and e-commerce infrastructure in the implementation scope (PricewaterhouseCoopers, 2025).

These physical components are important for the "shared vs dedicated" question. In many European markets, POS and ATM services are already delivered through vendor platforms, processors, and interbank utilities, suggesting high mutualisation potential if scheme specifications allow standardised upgrades (European Central Bank, 2025c; CIPA & ABI, 2024).

3. Methodology

This thesis applies a mixed qualitative–quantitative method. The qualitative part maps rulebook-aligned requirements to bank capabilities and technical components. The quantitative part combines published cost estimates with a scenario model that distributes costs across bank tiers and implementation models, explicitly modelling synergy and mutualisation.

3.1 Data sources

Primary sources are the attached ECB documents (preparation phase closing report; RDG progress reporting; DESP experimentation portal user guide; ECB note on investment costs), the PwC cost study commissioned by European banking associations, and an EBA guide for banks. For banking IT sourcing patterns and physical infrastructure outsourcing, the CIPA/ABI Economic Survey (financial year 2024) is used as an empirical reference for bank IT sourcing and cost structures in a large euro-area banking market (CIPA & ABI, 2024).

3.2 Analytical framework

The analytical framework has three layers:

1. Requirements layer: rulebook-aligned functional and non-functional requirements, including UX, brand and dispute management.
2. Capability layer: bank/PSP modules required to implement requirements (channels, payments hub, compliance, operations).
3. Implementation layer: sourcing and delivery models (in-house, hybrid, outsourced) and options for mutualisation across PSPs.

3.3 Bank tiering and sourcing maturity

To connect implementation models to bank reality, banks are grouped into tiers based on operational scale and IT maturity. The ECB cost note itself uses bank size clusters to illustrate cost distribution and synergies (European Central Bank, 2025c). In addition, the CIPA/ABI survey shows systematic differences in sourcing models by size: large banking groups tend to keep infrastructure and applications in-house, whereas small groups predominantly outsource data centres and applications; the survey also observes that POS and ATMs/kiosks are commonly outsourced thematic areas (CIPA & ABI, 2024).

3.4 Evaluation criteria

Implementation models are evaluated against criteria relevant for regulated PSPs: (i) control and governance; (ii) time-to-market and delivery risk; (iii) operational resilience and cyber risk; (iv) ability to comply with rulebook and supervisory expectations; (v) scalability and performance; and (vi) total cost of ownership (TCO).

4. Requirements and rulebook-aligned design

Banks' implementation choices must be grounded in scheme requirements. The digital euro rulebook work aims to standardise both functional requirements (what the scheme must do) and non-functional requirements (how it must perform and operate), including availability, performance, maintenance, security, and operational processes (European Central Bank, 2025a). The RDG also addresses minimum user experience requirements and brand rules so that end-users experience a consistent digital euro service independent of provider (European Central Bank, 2025b).

4.1 Functional requirement domains

For implementation planning, functional requirements can be grouped into domains that correspond to distinct bank capabilities:

Table 3. Rulebook-aligned functional domains and implementation focus

Domain	Implementation focus (bank/PSP)
Access management	Onboarding, identity, wallet creation, credential management, device binding, lifecycle management.
Liquidity management	Funding and defunding of digital euro holdings, links to deposit accounts, limits, and waterfall rules.
Transaction management	P2P and merchant payments, initiation, authorisation, confirmation, reversal/recall where applicable.
Offline payments	Offline value storage, double-spend prevention, limits, reconciliation, dispute/exception handling.
Value-added services	Conditional payments, programmability constraints, merchant services, analytics.
Dispute management & customer support	Case handling, error resolution, chargeback-like flows if defined, helpdesk integration.

4.2 Non-functional and operational requirements

Non-functional requirements typically drive the largest architectural and operational changes. For digital euro, they are expected to cover high availability, low-latency processing, strong security controls, privacy-by-design, robust key management, logging, monitoring, and change management. These requirements influence whether banks can centralise components, whether they need active-active architectures, and how much they can rely on third parties (European Central Bank, 2025a; Euro Banking Association, 2023).

4.3 Mapping requirements to bank modules

Table 4. High-level mapping of scheme requirements to bank modules

Requirement area	Impacted bank modules	Notes
Digital euro channel UX	Mobile/web banking, merchant acquiring UI, POS/ATM flows, ECB app interoperability	UX consistency, brand rules, accessibility
Customer lifecycle	KYC/identity, customer master data, device management, consent management	Onboarding, updates, deactivation, support
Payments processing	Payments hub, orchestration/middleware, fraud engines, limits, ledger posting	Real-time status, reversals, conditional flows
Funding & liquidity	Core banking deposit accounts, liquidity engine, treasury, intra-day management	Funding/defunding, limits, waterfall
Compliance & risk	AML monitoring, sanctions screening, fraud, cyber security operations	Scheme-specific risk models, audit trail
Operations	Monitoring, incident management, reconciliation, reporting, dispute/case mgmt	SLA, resilience, scheme reporting
Acceptance infrastructure	POS terminals, e-commerce checkout, ATMs/branch devices	Hardware upgrades, certification, shared processors

5. Technical integration reference architecture

This chapter develops a reference architecture that enables a bank to integrate with the DESP while limiting disruptive change to the core banking stack. The architecture is based on separation of concerns: (i) scheme connectivity and protocol handling; (ii) orchestration and business rules; (iii) core ledger posting and liquidity; and (iv) channel and user experience.

5.1 Connectivity patterns: direct vs shared connector

Two connectivity patterns are observed across European payment schemes and are directly applicable to the digital euro: a direct model where each bank builds and operates its own DESP connector, and a shared connector model where multiple PSPs use a mutualised access layer (e.g., via a sector utility, vendor hub, or interbank service provider). The ECB's cost analysis explicitly considers mutualisation and synergy factors such as shared infrastructures, common providers, and group-wide solutions, and concludes that banks should not be assumed to implement digital euro capabilities on a stand-alone basis (European Central Bank, 2025c).

A shared connector can provide: standardised API adaptors, security and key management, certification tooling, and replayable test environments. Banks can then focus on institution-specific business rules (e.g., customer policies, risk appetites) and channel integration.

5.2 Anti-corruption layer and scheme adaptor

To isolate legacy cores from scheme volatility, a dedicated "scheme adaptor" (anti-corruption layer) is recommended. It translates DESP messages and rulebook semantics into the bank's internal canonical payment model, handling:

- Protocol translation (REST/JSON to internal events/messages).
- Authentication and authorisation (e.g., portal credentials, later mTLS, OAuth or scheme-specific credentials).
- Message integrity (digital signatures on requests such as POST/PUT as demonstrated in the DESP portal).
- Idempotency, retries, and ordering control for real-time scheme interactions.
- Schema evolution handling (semantic versioning) to reduce breaking changes (European Central Bank, 2025d).

5.3 Orchestration and business rules

Above the scheme adaptor, a digital euro orchestration service is responsible for bank-specific policies and workflow coordination. It typically includes: limit enforcement, channel authorisation rules, routing between online and offline flows, dispute triggers, and liquidity waterfall logic that interacts with deposit accounts and internal ledgers. This layer is where banks differentiate their customer experience while still complying with minimum UX and brand requirements (European Central Bank, 2025b).

5.4 Core banking and accounting integration

Digital euro holdings and payments must be reflected in a bank's general ledger, customer account statements, and regulatory reporting. A pragmatic approach is to treat digital euro positions as a distinct "wallet holding" linked to an underlying funding account (e.g., a designated deposit account). Depending on scheme design, banks may need real-time posting into core banking, or may use a near-real-time sub-ledger with periodic reconciliation. Tier 1–2 banks often prefer direct integration into existing payment hubs and core ledgers for control and auditability, whereas smaller banks may rely on vendor cores and hosted ledger services (CIPA & ABI, 2024).

5.5 Offline architecture and device provisioning

Offline payments introduce additional components: secure elements, offline value limits, transaction counters, and reconciliation services. Banks must implement device provisioning and lifecycle management that binds a customer identity and wallet to device hardware, including processes for lost devices, resets, and recovery. Because many banks already outsource POS and ATM operations, mutualised offline provisioning and terminal certification services are plausible shared components, provided that security and liability models are clarified in the rulebook (PricewaterhouseCoopers, 2025; CIPA & ABI, 2024).

6. Bank and PSP module impact analysis

Digital euro integration affects far more than a single API connector. It impacts end-user channels, payment processing, risk and compliance, liquidity and treasury, accounting, and operational support. The impact differs by bank tier because architectural freedom, sourcing models, and operational scale vary widely across the market (European Central Bank, 2025c; CIPA & ABI, 2024).

6.1 Channel layer

Banks must integrate digital euro journeys into existing channels: mobile and web banking, branch/assisted channels, and merchant-facing acquiring channels. A scheme-provided app can exist as an optional channel; however, most banks will prefer a unified customer experience within existing apps to preserve engagement and reduce support costs.

Table 5. Channel-level impact areas

Channel	Digital euro changes	Implementation notes
Mobile/Web banking	Wallet view, funding/defunding, P2P payments, merchant QR/NFC, transaction history	Strong UX and security requirements
Merchant acquiring portals	Onboarding merchants, configuring acceptance, settlement views	Often outsourced/processor-driven
POS terminals	NFC/contactless or QR acceptance, scheme certification, offline fallbacks	Hardware+software upgrades
ATMs/branch devices	Cash-in/cash-out related services if supported; user assistance; offline support	Frequently outsourced in practice
Call centre / help desk	Dispute/case management, device recovery, customer education	Training and case tooling needed

6.2 Payment processing and orchestration

Most banks operate a payments hub or payment engine that handles SEPA, instant payments, cards, and internal transfers. The digital euro adds a new scheme with real-time interactions and potentially new primitives such as reservations for conditional payments. Integration patterns include: (i) adding digital euro as a new “rail” in the payment orchestration layer; (ii) isolating it in a dedicated microservice that publishes canonical events; or (iii) leveraging vendor payment hubs that add scheme support as a module.

Table 6. Processing and orchestration components

Component	Role	Notes
Scheme adaptor/connector	Protocol handling, security, versioning, idempotency	Can be shared across PSPs
Digital euro orchestration	Policy rules, workflow coordination, error handling	Usually bank-specific
Limits engine	Holding limits, customer limits, offline limits, waterfall rules	Rulebook-driven + bank policies
Fraud detection	Real-time scoring, device fingerprinting, anomaly detection	Can be shared partially; data sensitivity
Reconciliation service	Match DESP statuses with internal postings; investigate exceptions	High automation needed

6.3 Liquidity, funding, and treasury

Funding and defunding flows connect digital euro holdings to deposit accounts or other funding sources. Banks must implement liquidity monitoring, intraday management, and waterfall logic that meets scheme rules while managing balance-sheet impacts. These components are typically closely tied to core banking and treasury systems and are therefore less suitable for full outsourcing.

6.4 Compliance, risk, and security operations

Compliance obligations (AML/KYC where applicable, sanctions screening, fraud prevention) and cyber security are core responsibilities for PSPs. Even if some components (e.g., sanctions screening engines) are sourced from vendors, governance and accountability remain with the PSP. The DESP portal's emphasis on message integrity (digital signatures) illustrates that strong cryptographic controls will be foundational to the scheme's security model (European Central Bank, 2025d).

6.5 Data, reporting, and analytics

Banks must extend data models, reporting pipelines, and audit trails to include digital euro transactions and holdings. This includes customer statements, regulatory reporting, operational dashboards, and potentially new scheme reporting obligations. A key design question is whether analytics are performed on enriched, bank-side data (preferred for privacy and governance) or whether shared utilities offer aggregated analytics services.

7. Shared integration: what can be mutualised across PSPs?

A major determinant of both cost and delivery risk is the degree to which PSPs can share components. The ECB's analysis of investment costs explicitly incorporates synergy drivers such as common providers, shared infrastructures, and group-wide solutions, and discusses vendor concentration as a factor that can enable higher mutualisation by reducing duplication of connectivity and processing stacks (European Central Bank, 2025c).

7.1 Design principles for mutualisation

- Standardise what is commoditised: connectivity, protocol handling, certification tooling, and non-differentiating operations.
- Keep institution-specific risk and policy local: customer eligibility, fraud strategy, complaints handling, and supervisory interaction.
- Mutualise physical acceptance where markets already share processors (POS, ATMs, acquiring) and upgrade can be certified once.
- Ensure a clear liability and governance model: shared components require explicit RACI and auditability.

7.2 Component-level shareability matrix

Table 7. Shareability assessment for digital euro integration components

Component	Shareability	Rationale
DESP connector / API adaptor	High	Commodity connectivity; can be offered by sector utilities or vendors.
Key management / signing service	Medium	Shareable if strong segregation & HSM tenancy; governance critical.
Certification & conformance testing toolkit	High	Natural candidate for shared sandbox, test harnesses, and automated evidence.
Customer onboarding (KYC)	Low	Bank-specific risk appetite and regulatory obligations; can share tooling not decisions.
Wallet UI / channel integration	Low–Medium	Minimum UX/brand rules constrain design; banks differentiate in channels.
Limits & waterfall engine	Medium	Core logic rulebook-driven; parameterisation bank-specific.
Fraud & anomaly detection	Medium	Models can be shared but require data governance and

		privacy safeguards.
Reconciliation and reporting pipeline	Medium	Can share patterns/platforms; data remains bank-specific.
Customer support / dispute tooling	Medium	Platforms can be shared (case systems), but customer interaction local.
POS terminal software upgrades	High	Often processor-driven; certification can be mutualised (PricewaterhouseCoopers, 2025).
ATM/kiosk upgrades	High	ATM estates often outsourced; upgrades can be delivered by shared providers (CIPA & ABI, 2024).
Offline secure element provisioning	Medium	Shareable service if device identity & keys are tenant-isolated.

7.3 Shared integration beyond software: POS, ATMs, and networks

The PwC cost study explicitly includes POS terminals, ATMs, and e-commerce infrastructure in scope, confirming that hardware and acceptance channels are material cost drivers (PricewaterhouseCoopers, 2025). The CIPA/ABI survey reports that POS and ATMs/kiosks are thematic areas where IT activities are primarily outsourced, indicating that many banks already rely on specialised external providers for these infrastructures (CIPA & ABI, 2024).

This creates a practical path to mutualised implementation: if processors and terminal vendors implement the scheme once, many PSPs can adopt the upgrade with limited institution-specific work. However, end-to-end security and liability must remain clear, especially for offline functionality where device security and reconciliation affect financial risk.

8. Implementation models for banks and PSPs

Based on the research outline, three archetypal implementation models are analysed: (i) in-house; (ii) hybrid; and (iii) outsourced. In practice, banks often operate mixed models across domains (e.g., in-house payments hub but outsourced POS processing). The model choice is constrained by sourcing maturity, vendor landscape, and the mutualisation opportunities available in each market (European Central Bank, 2025c; CIPA & ABI, 2024).

8.1 In-house model

In the in-house model, the bank builds and operates the DESP connector, orchestration, and most supporting services internally. This maximises control, enables deep integration with the bank's existing payments hub and risk engines, and can support high customisation. However, it requires strong engineering capacity, specialised cryptography and security skills, and long-term operational commitment.

8.2 Hybrid model

In the hybrid model, banks retain control of customer-facing journeys and critical risk decisions while sourcing commoditised components. Typical hybrid choices include: using a shared DESP connector, buying a vendor digital euro module for the payments hub, or using managed services for monitoring and conformance testing. Hybrid models align well with the ECB's emphasis on synergy factors and the feasibility of shared infrastructures (European Central Bank, 2025c).

8.3 Outsourced model

In the outsourced model, a vendor or sector utility provides most of the digital euro stack, including connectivity, orchestration, and possibly even channel components. This can accelerate time-to-market and reduce upfront investment for smaller banks. The trade-off is reduced control, greater vendor dependency, and the need for rigorous oversight of third-party risk and operational resilience.

Table 8. Comparison of implementation models

Dimension	In-house	Hybrid	Outsourced
Criterion	In-house	Hybrid	Outsourced
Control & governance	High	Medium–High	Low–Medium
Time-to-market	Medium	High	High
Upfront investment	High	Medium	Low–Medium
Operational complexity	High	Medium	Medium (vendor-managed)
Ability to differentiate UX	High	High	Low–Medium
Third-party risk	Low–Medium	Medium	High

Best fit (typical)	Tier 1–2	Tier 2–3	Tier 3–4

8.4 Implementation models and existing sourcing patterns

Empirical sourcing patterns indicate that outsourcing is already common for smaller institutions. In the CIPA/ABI survey, large groups are predominantly insourcing, medium groups predominantly use facility management (applications in-house with outsourced data centre infrastructure), and small groups largely rely on outsourcing for data centres and applications (CIPA & ABI, 2024). This suggests that implementation model recommendations should align with existing operating models rather than impose a one-size-fits-all approach.

9. Cost and quantitative assessment

Cost assessments are essential because the digital euro's total implementation burden depends heavily on mutualisation. The ECB's note on investment costs reviews industry estimates and shows that incorporating realistic synergy factors can reduce high, stand-alone cost estimates to a range broadly around €4.0–€5.77 billion for the euro-area banking sector over a four-year period (European Central Bank, 2025c).

9.1 Baseline cost scenarios from published studies

The ECB's cost note summarises a PwC cost study and adjusts its baseline by applying calibrated synergy factors. Under these adjustments, the PwC base scenario results in an estimated €5.77 billion investment cost for the euro-area banking sector, while a high-synergy scenario results in about €5.07 billion. The ECB also cites that other banking sector studies imply a range around €4.0–€4.2 billion after adjustment (European Central Bank, 2025c).

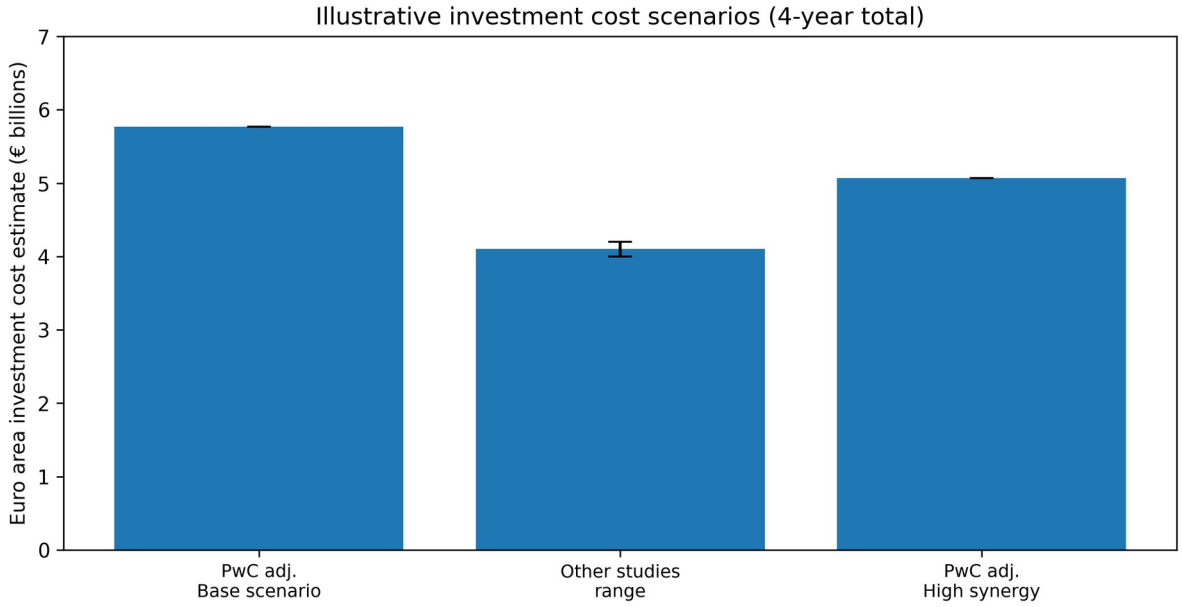

Figure 2. Illustrative investment cost scenarios reported/adjusted in the ECB note (four-year total).

9.2 Cost by bank size cluster

The ECB note also presents indicative per-bank average cost figures by size cluster for the PwC study and the adjusted values. These figures illustrate that absolute costs rise with bank size, but the affordability challenge is often greatest for smaller banks whose fixed-cost burden is high relative to IT budgets.

Table 9. Indicative per-bank average costs by size cluster (from ECB note)

Size cluster	PwC (per-bank average)	ECB-adjusted (per-bank average)
> €1 trillion assets	€182m	€152m
€100bn–€1tn assets	€106m	€89m
€30bn–€100bn assets	€29m	€24m
< €30bn assets	€9m	€8m

9.3 Drivers of cost mutualisation

The ECB analysis identifies synergy drivers such as common providers, shared infrastructures, group-wide solutions, and vendor concentration. In markets with shared processors and utilities, connectivity and acceptance upgrades can be implemented once and reused by multiple PSPs, reducing duplication (European Central Bank, 2025c).

The PwC study's inclusion of POS terminals, ATMs, and e-commerce infrastructure highlights that acceptance upgrades are a major cost driver, and also a major opportunity for mutualisation because these infrastructures are often delivered via common processors (PricewaterhouseCoopers, 2025).

9.4 Additional scenario model (illustrative)

To complement published aggregates, an illustrative scenario model is constructed to show how shared integration choices shift costs between bank tiers. The model is not a forecast; it is a sensitivity analysis that demonstrates directional effects. It assumes that a portion of total costs is attributable to components with high shareability (connector, certification tooling, terminal upgrades), while the remainder is bank-specific (channel integration, compliance integration, local operations).

Table 10. Illustrative mutualisation scenario assumptions

Parameter	Setting	Notes
Assumption	Value	Interpretation
Shareable cost share (all PSPs)	35%	Connector + certification + acceptance upgrades (illustrative).
Savings on shareable portion under high mutualisation	40%	Savings via utilities/vendor hubs and shared terminal upgrades.
Implied total savings vs baseline (€5.77bn)	~€0.81bn	Close to the ECB high-synergy delta (5.77 → 5.07).

The scenario is consistent with the ECB note's observation that realistic synergy assumptions materially reduce investment cost estimates. The main analytical implication is that policy and market design that enable mutualisation—particularly for smaller banks—can be decisive for broad market coverage and competition.

10. Recommendations: implementation models by bank tier

This chapter synthesises the architectural and cost analysis into practical recommendations. The goal is not to prescribe a single model, but to indicate which model is typically most effective given bank tier, sourcing maturity, and the availability of shared utilities.

10.1 Tier definitions

For the purposes of this thesis, tiers are defined by a combination of size, complexity, and IT maturity:

Table 11. Bank tiering used in this thesis (indicative)

Tier	Indicative characteristics	Typical constraints
Tier 1	G-SIB / large significant institutions (>€1tn assets, complex multi-country stacks)	Strong engineering, high control needs
Tier 2	Large banks (€100bn–€1tn assets, significant payment volumes)	Mix of in-house and vendor platforms
Tier 3	Medium banks (€30bn–€100bn assets)	Often rely on vendor cores/payment hubs; selective in-house
Tier 4	Small/LSI banks (<€30bn assets)	High outsourcing propensity; benefit most from utilities

10.2 Decision matrix and recommended models

Figure 3 provides an indicative decision matrix linking tiers to recommended implementation models. The core idea is that larger banks can justify in-house build for critical components, while smaller banks should prioritise outsourced or highly mutualised models to manage fixed costs. Hybrid models are broadly applicable where shared connectors and vendor modules exist.

Indicative implementation model recommendations by bank tier

	In-house	Hybrid	Outsourced
Tier 1 (G-SIB/SI > €1T assets)	Preferred (core services) + selective vendors	Also viable (share connector, keep risk/ledger)	Limited (use only for non-core)
Tier 2 (Large €100B–€1T)	Selective (integration & channels)	Preferred (shared connector + vendor platforms)	Viable for channels/ops, keep compliance
Tier 3 (Medium €30B–€100B)	Niche (if strong IT)	Preferred (vendor+shared hub)	Also viable (especially IPS/consortia)
Tier 4 (Small/LSI < €30B)	Rare (high cost/skills)	Viable (if joining shared utility)	Preferred (outsourcing & mutualisation)

Figure 3. Indicative implementation model recommendations by bank tier (decision matrix).

10.3 Practical roadmap for PSP integration

A rulebook-aligned implementation roadmap can be structured into phases:

Table 12. Rulebook-aligned implementation roadmap (high-level)

Phase	Key activities
Phase 0 – readiness	Establish programme governance, map rulebook domains to internal owners, assess sourcing options, and join test communities.
Phase 1 – connectivity	Implement or procure DESP connector, security/key management, and certification/testing toolchain.
Phase 2 – core capabilities	Integrate holdings view, funding/defunding, limits and waterfall, transaction initiation and status tracking.
Phase 3 – channels & acceptance	Embed journeys into mobile/web, integrate merchant acquiring and terminal upgrades (POS/e-commerce/ATM).
Phase 4 – offline enablement	Provision secure elements, define offline limits, implement reconciliation and exception handling.
Phase 5 – value-added services	Implement conditional payments/reservations, analytics, and new services within scheme constraints.

10.4 Governance and shared utility considerations

Shared integration requires governance. Banks considering mutualised solutions should evaluate: ownership structure, liability model, auditability, resilience (including exit strategies), and data segregation. The CIPA/ABI survey notes that negotiating ad hoc contractual clauses with public cloud providers can be limited for some groups, highlighting the importance of procurement and exit planning when outsourcing critical digital euro components (CIPA & ABI, 2024).

11. Conclusion

Digital euro integration is a multi-layer transformation that spans scheme connectivity, bank back-office processes, customer-facing channels, and physical acceptance infrastructure. The DESP and the RDG rulebook work provide a foundation for standardisation, but PSPs must translate requirements into concrete architectures and operating models.

This thesis proposed a rulebook-aligned reference architecture that isolates scheme volatility through a scheme adaptor and orchestration layer, mapped the impacted bank modules, and analysed what can be mutualised across PSPs. A key finding is that mutualised integration—covering both software and hardware acceptance upgrades—can materially reduce costs and delivery risk, consistent with the ECB's synergy-based cost adjustments and the PwC study's scoped cost drivers.

Finally, the tiered implementation model recommendations show that broad PSP coverage is achievable if shared utilities and vendor ecosystems are leveraged appropriately, particularly for smaller institutions. Future work should refine the cost model with more granular country-level data, validate architectural assumptions against the final rulebook and legislative text, and extend the analysis to cross-border use cases and interoperability with instant payments.

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Appendix A. Abbreviations

Table A1. Abbreviations used in this thesis

Abbreviation	Meaning
CBDC	Central Bank Digital Currency
DESP	Digital Euro Service Platform
ECB	European Central Bank
RDG	Rulebook Development Group
PSP	Payment Service Provider
DCA	Digital Currency Account / Digital euro holding account (context-dependent)
HSM	Hardware Security Module
POS	Point of Sale
UX	User Experience
API	Application Programming Interface

Appendix B. Checklist for aligning a bank programme with the rulebook domains

Table B1. Implementation checklist aligned to scheme domains

Rulebook domain	Programme checklist (indicative)
Access management	Own onboarding journey; identity & device binding; credential lifecycle; customer support playbooks
Transaction management	Payment initiation, confirmation, status tracking; error and exception flows; dispute triggers
Liquidity management	Funding/defunding; intraday monitoring; limits & waterfall logic; reconciliation
Offline payments	Secure element provisioning; offline limits; double-spend controls; reconciliation and recovery
User experience & brand	Minimum UX compliance; brand rules; accessibility; customer education materials
Operations & resilience	Monitoring; incident management; change management; audit trails; exit strategy for third parties
Acceptance infrastructure	POS/e-commerce/ATM upgrades; certification; merchant onboarding impacts; processor coordination