

Transferable cloud capacity rights with usage-backed financing: An entitlement-ledger architecture and market mechanism for managed hosting providers

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ARTICLEINFO

Received: 03 Sept 2024

Revised: 20 Oct 2024

Accepted: 28 Oct 2024

ABSTRACT

Managed hosting providers sell capacity month by month, so their revenue moves with churn and with each customer’s changing demand. Customers avoid long commitments because committed capacity they cannot use is a sunk cost. This paper presents an architecture and market mechanism, Transferable Cloud Capacity Rights with Usage-Backed Financing (TCCR-UBF), in which a provider issues standardised contractual rights to future capacity that a verified business customer can consume or, with the provider’s approval, transfer to another verified customer inside a closed system, and in which committed service payments can support financing of migration work through a permitted lender. The design places an admission controller and a capacity reserve floor above any marketplace matching, records rights in a conventional entitlement ledger with signed, hash-chained audit records, and settles transfers atomically with the provider’s orchestration layer. We derive the product catalogue, the market rules, the lifecycle state machine, the component model, and the reconciliation procedure, and we evaluate the economics with a portfolio simulation of 400 customers over 24 months under base, upside, downside, stress, and reverse-stress scenarios. In the base scenario the transferable commitment matches a fixed commitment on provider contribution while reducing the coefficient of variation of monthly revenue from 0.149 to 0.110 and raising utilisation from 0.646 to 0.678. The flexibility premium needed to offset cannibalisation of list-price sales rises by about one percentage point for every ten points of cannibalisation, and higher marketplace liquidity reduces provider gain when cannibalisation is high. A lifecycle simulation of a 300-customer entitlement ledger confirms that the state machine, admission control, and settlement rules hold under load, and a threat model with 32 controls covers account takeover, double transfer, capacity overselling, settlement fraud, and correlated failover demand. We conclude with UK-centred regulatory and accounting considerations, a gated pilot design with pre-declared stop conditions, and a provider implementation template.

Keywords: cloud economics; capacity rights; managed hosting; entitlement ledger; admission control; electronic markets; revenue management; design science

1 INTRODUCTION

A managed hosting provider runs servers, storage, backup, and support for business customers and usually bills them by the month. Revenue rises and falls with churn and with each customer’s workload. To smooth it, providers offer discounts for longer commitments, and customers hesitate, because a two-year commitment to capacity they may not use is money lost. The public cloud providers have faced the same trade-off. Amazon Web Services opened a marketplace in 2012 where customers can sell reserved instances they no longer need [1, 2]. Microsoft added exchanges and capped refunds for Azure reservations in 2019 [3]. AWS later introduced Savings Plans, which commit spend

rather than instance type [4]. At the same time, UK regulators have found that committed spend discounts, egress fees, and technical barriers make cloud customers sticky and reduce switching [5, 6].

This paper presents a model that a smaller managed hosting provider can adopt, and the architecture needed to run it safely. We call it Transferable Cloud Capacity Rights with Usage-Backed Financing (TCCR-UBF). The provider sells standardised contractual rights to future capacity. A verified business customer can consume the rights, or transfer unused rights to another verified customer, with the provider's approval, inside a closed system. Committed service payments can also support financing of migration and deployment work arranged with a permitted lender. The provider earns commitment revenue, a premium for the transfer option, transfer fees, and possibly referral or servicing fees.

The idea is simple. Its risks are not. A right that can be transferred starts to resemble a financial instrument. A marketplace inside a hosting company can be manipulated, can leak information, and can push capacity beyond what the hardware can deliver. Transfers can cannibalise list-price sales. Financing brings credit risk and credit regulation. Accounting for prepaid, transferable, expiring rights involves judgement about breakage, financing components, and who is principal in a transfer. We therefore treat the model as a hypothesis and give equal weight to its upside and to its failure modes.

The contributions are as follows. First, a formal definition of a cloud capacity right, its lifecycle, and its boundary conditions, written so that rights remain service entitlements rather than instruments. Second, a vendor-neutral reference architecture in which an entitlement ledger, an admission controller with a reserve floor, and an atomic settlement service sit above the transfer marketplace, using a conventional database with signed audit records rather than a blockchain. Third, a product catalogue and a set of market rules derived from evidence-supported analogues. Fourth, a unit-economics model and simulation that identify the break-even flexibility premium against cannibalisation and the conditions under which the transferable design loses to a plain commitment. Fifth, a threat model, a regulatory and accounting issue register centred on the UK, and a gated pilot protocol with stop conditions, so that a provider can test the model and, if the evidence says so, reject it. The work follows the design science method [7, 8] and uses only sources dated on or before 30 September 2024.

The paper is organised as follows. Section 2 reviews the background. Section 3 defines the capacity-right model. Section 4 presents the architecture. Section 5 gives the market mechanism, admission control, and pricing. Section 6 reports the simulation-based evaluation. Section 7 presents the security analysis. Section 8 sets out compliance and accounting considerations. Section 9 describes the pilot design and implementation template. Section 10 discusses the results, and Section 11 concludes.

2 BACKGROUND AND RELATED WORK

2.1 Cloud pricing and capacity control

Wu et al. survey cloud pricing and group models into static, dynamic, and market-based schemes [9]. Kilcioglu et al., using Azure usage data, find that aggregate demand is smooth and that customers show low variance in utilisation, which weakens the case for dynamic pricing [10]. Ben-Yehuda et al. show that early EC2 spot prices were often set by a reserve-price algorithm rather than by supply and demand [11]. Dierks and Seuken show that adding a spot market next to fixed-price products can raise provider profit under some conditions [12]. Toosi et al. model how a provider should limit how much capacity it sells as reserved, on-demand, and spot [13]. Nunez et al. show that slack in contract capacity can be reallocated to raise provider value [14]. Rogers and Cliff propose a broker that buys reserved capacity and resells it on demand [15]; Cartlidge and Clamp correct their model and find the profit window narrower [16]. Cohen et al. and Tomás and Tordsson show how overcommitment can be bounded by chance constraints and risk assessment [17, 18]. Two lessons follow for our design: commitments and capacity control are the provider's main levers, and any overcommitment must be measured against a risk limit.

2.2 Lock-in and switching

Opara-Martins et al. surveyed UK businesses and found that lock-in at the data, application, and contract level shapes migration decisions [19]. Ofcom found that egress fees at the largest providers were five to ten times those of some smaller providers and likely above incremental cost, that committed spend discounts reward consolidation with one provider, and that few customers achieve the benefits of multi-cloud; Ofcom referred the market to the Competition and Markets Authority [5]. The CMA's working paper on committed spend agreements found that such agreements are common and growing, that they influence where new workloads go and whether existing ones move, and that switching barriers are high [6]. The EU Data Act requires providers of data-processing services to remove obstacles to switching and to phase out switching charges [20]. These findings motivate the hypothesis that a permissioned transfer right can reduce the perceived cost of commitment without the provider giving up the commitment itself.

2.3 Capacity exchanges and other analogues

Two cloud capacity exchanges are instructive. The Deutsche Börse Cloud Exchange, a neutral marketplace for standardised infrastructure units, launched in 2015 and was closed in 2016 while its shareholders evaluated the business model [21]. Bandwidth trading in the early 2000s failed to gain liquidity because provisioning could not keep pace with trades and price volatility was too low to attract participants [22, 23]. Table 1 compares these and other analogues. The AWS Reserved Instance Marketplace lets a customer sell the remaining term of a standard reserved instance to another AWS customer; at launch, AWS charged a 12% seller fee, required a 30-day minimum holding period and a US bank account, and stated that marketplace instances carry the same capacity reservation as instances bought directly [2, 24]. Azure reservations can be exchanged within the same type and refunded up to a cap in a rolling 12-month window; Microsoft reserved a 12% early-termination fee that it did not charge at the time [3]. The GB electricity capacity market shows that a capacity product must define the deliverable precisely, include penalties for non-delivery, and be procured against a reliability target [25, 26]. Airline revenue management shows how to protect inventory for higher-value demand and how to overbook against measured no-shows [27, 28]. Factoring works where receivables are verifiable [29]; leasing extends debt capacity because the lessor can repossess [30]; revenue-based finance shows adverse selection and revenue hiding among takers [31]. Platform pricing theory shows that the price structure across sides matters, not just the level [32], and market design shows that markets need thickness, must manage congestion, and must be safe to use [33], while quality uncertainty can unravel a market [34].

Table 1 Comparable mechanisms and what transfers to TCCR-UBF

Analogue	Transfer	Fee or premium	Quality equivalence	Supply control	Transfers to the design	Does not transfer
AWS RI Marketplace (2012)	Seller lists remaining term; buyer pays upfront	12% seller fee; 30-day hold	Exact attribute match; convertible RIs excluded	AWS controls issuance	Issuer approval; minimum hold; attribute matching	US-specific legal and tax design
Azure reservation exchange (2019)	Exchange within type; capped refund	12% fee reserved	Same reservation type	Provider	Flexibility is priced; refund caps	No third-party transfer
Deutsche Börse Cloud Exchange (2015–2016)	Neutral multi-provider exchange	Exchange fees	Standardised units	Provider-side	Standard lots	Failed for lack of liquidity

Analogue	Transfer	Fee or premium	Quality equivalence	Supply control	Transfers to the design	Does not transfer
Bandwidth trading (c. 2000)	Exchanges and pooling points	Commodity pricing	Poor; routes not fungible	Weak	Settlement must match provisioning	Markets never matured
GB capacity market (2014–)	Secondary trading of obligations	Auction clearing price	De-rated by technology	Central buyer, reliability target	Precise deliverable; penalties	Statutory central buyer
Airline revenue management	Limited	Change fees	Cabin class	Overbooking against no-shows	Protect inventory; price flexibility	Independent no-shows
Factoring and leasing	Assignment of receivables; restricted lease assignment	Discount rate; lease rate	Obligor or asset specific	n/a	Verifiable cash flows support finance	Executory service is not a receivable
Revenue-based finance	Not transferable	Fee or cap	n/a	n/a	Screen for adverse selection	Provider should not lend

2.4 Resilience, accounting, and regulation

A transferable right is only worth what the provider can deliver. The Uptime Institute's 2024 outage analysis reports that 54% of surveyed operators' most recent significant outage cost more than \$100,000, that 55% of operators had an outage in the past three years, and that third-party provider issues caused 9% of impactful outages [35]. Many hosting customers are regulated firms that must identify important business services, set impact tolerances, and map their dependencies, including cloud providers [36, 37]. The Financial Services and Markets Act 2023 lets HM Treasury designate critical third parties to the financial sector [38, 39]; in the EU, DORA and NIS2 set requirements for ICT providers to financial entities and for cloud and data-centre operators [40, 41]. On accounting, IFRS 15 governs breakage on unexercised rights, material rights, and significant financing components [42]; US GAAP has converged on the core model and adds guidance on breakage for prepaid stored-value products [43, 44]. A right to pooled capacity is generally not a lease, because a capacity portion that is not physically distinct is not an identified asset under IFRS 16 [45], consistent with the Interpretations Committee's 2019 decision on hosted software [46]. Whether a transferable service entitlement is a payment instrument, electronic money, a security, or a voucher for VAT is governed in the UK by the Payment Services Regulations 2017, the Electronic Money Regulations 2011, the Financial Services and Markets Act 2000 and its Regulated Activities Order, and Schedule 10B of the Value Added Tax Act 1994 [47, 48, 49, 50, 51]. None of these authorities addresses cloud capacity rights directly, which is the gap this paper works in.

3 CAPACITY-RIGHT MODEL

3.1 Definition

A cloud capacity right (CCR) is a contractual entitlement, issued by a managed hosting provider to a verified business customer, to receive a defined quantity of a defined hosting service, of a defined quality, in a defined region, during a defined time window. The holder may consume it, or, with the provider's approval, transfer it to another verified customer. It expires unused at the end of its window. Usage-backed financing (UBF) is a loan or instalment

arrangement, provided by a permitted lender, whose repayment schedule is sized against the customer's committed service payments and which funds migration or deployment work.

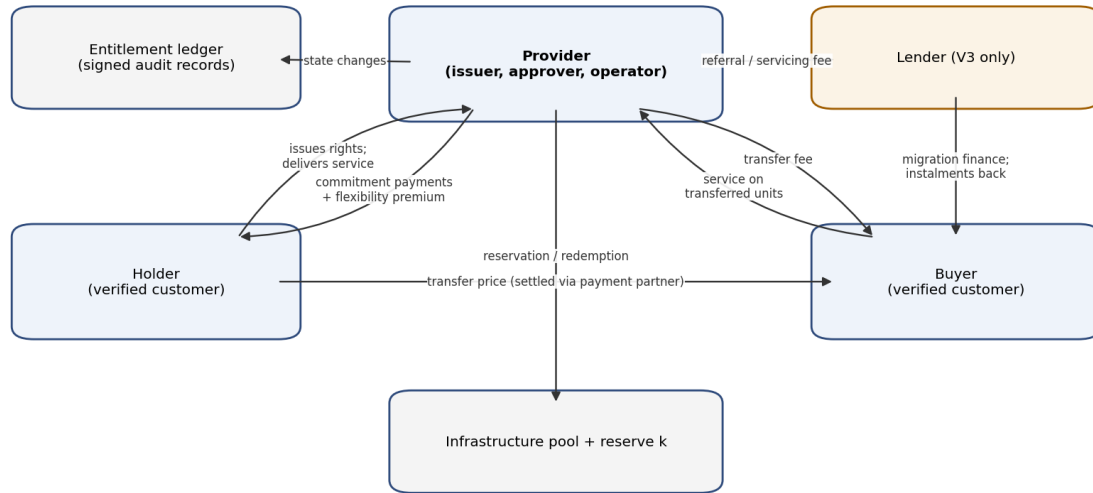
Six features define the conservative design: business customers only; a closed provider ecosystem; rights denominated in service units, not money; no cash redemption by the customer; transfers only among verified customers with provider approval before settlement; and fixed expiry with a defined service class. Nothing about the rights promises appreciation or yield. Table 2 gives the definitions and boundary conditions.

Table 2 Definitions and boundary conditions

Term	Definition	Boundary
Capacity unit	Smallest standardised quantity of a service class a right can denominate	Measured automatically by existing metering
Service class	Named product with quality attributes, region, tenancy, support tier	Two units are equivalent only within one class
Commitment	Customer's promise to pay for C units for T months	Creates the rights; payable regardless of use
Redemption	Consumption of a right by provisioning in its window	No redemption outside the window
Transfer	Change of holder, approved by the provider, with settlement	Verified counterparties only
Expiry	End of the window; unredeemed units lapse	No refund
Flexibility premium f	Extra price for the transfer option	Charged on the discounted price
Transfer fee tau	Provider's charge on a settled transfer	Paid at settlement
Reserve ratio k	Capacity held above committed units	Admission control input
Closed loop	Rights usable only with the issuer; no cash-out	Central boundary condition

3.2 Actors and value flows

Figure 1 shows the actors and value flows. The holder pays the provider for the commitment and the premium. The provider issues rights, reserves capacity with a reserve ratio, and delivers service. A buyer pays the holder for a transferred right through a payment partner, and the provider takes a fee. In the finance-enabled variant, a lender pays migration invoices and the customer repays in instalments; the provider may receive a referral or servicing fee where permitted. The provider never holds funds on behalf of either party, and no right is pledged to a lender.

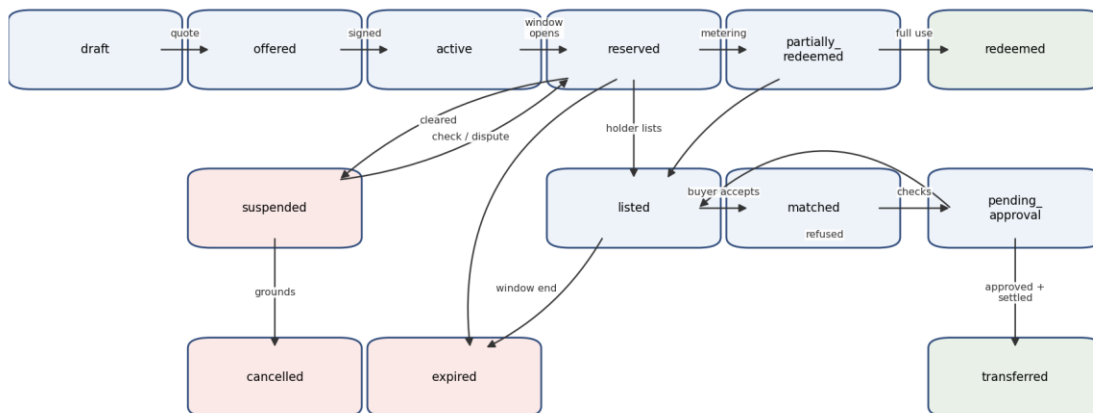


Provider approval and admission control sit between every transfer and settlement.

Fig. 1 Actors and value flows in TCCR-UBF

3.3 Lifecycle state machine

A right moves through thirteen states: draft, offered, active, reserved, listed, matched, pending_approval, transferred, partially_redeemed, redeemed, expired, suspended, and cancelled. Figure 2 shows the transitions. Issuance takes a right from draft to offered when a quote is produced, and to active when the contract is signed and any upfront payment is received; both steps require the admission check in Section 5.3. The right becomes reserved when its window opens and capacity is earmarked in orchestration. Metering moves it to partially_redeemed or redeemed. A holder may list unused units if the product is transfer-eligible, the remaining window is at least the minimum, and the holder is in good standing. A verified buyer's acceptance creates a match; the system raises an approval case; the provider approves or refuses; and settlement completes the transfer. Suspension is reversible and is used for verification lapses, sanctions alerts, disputes, and incidents. Cancellation is terminal and applies the contract's refund rule. Every transition writes a signed audit record. The buyer of a transferred right receives a new reserved record that links to the transferred one, so that provenance is preserved.



Green = value delivered; red = terminal or frozen. Every transition writes a signed audit record. The buyer receives a new reserved record linked to the transferred one.

Fig. 2 Capacity-right lifecycle

3.4 Variants

We define a minimum viable design with no transfers at first, and three variants: a conservative closed loop with bilateral, manually approved transfers (V1); a managed-transfer marketplace using a bulletin board with provider approval (V2); and a finance-enabled deployment adding a third-party lender (V3). Each variant adds a revenue stream and a set of gates in the pilot protocol.

3.5 Hypotheses

The framework rests on eight testable propositions. H1: transferability increases customers' willingness to enter longer commitments. H2: longer commitments reduce monthly recurring revenue volatility. H3: a permissioned secondary exchange reduces perceived lock-in without materially raising churn. H4: transferable rights improve utilisation only when products are standardised and admission control binds. H5: a flexibility premium plus a transfer fee can offset cannibalisation of ordinary hosting revenue. H6: usage-backed migration financing increases conversion among customers facing high upfront migration costs. H7: operational complexity rises non-linearly as rights become more granular, portable, or time-sensitive. H8: a closed-loop contractual design presents lower regulatory and abuse risk than freely tradable tokenisation. Section 6 evaluates H2, H4, and H5 by simulation; H1, H3, H6, and H7 require the pilot in Section 9; H8 is addressed by the security and compliance analysis.

4 ARCHITECTURE

4.1 Design principles

Four principles shape the architecture. Physical capacity dominates financial matching: the admission controller and the reserve floor sit above the marketplace, and a transfer that would push a pool past its limit is refused regardless of price. The ledger is conventional: a relational store with serialisable state transitions, one writer path, and an append-only, hash-chained, signed audit log gives tamper evidence without giving up the provider's control. Settlement is atomic: payment confirmation, ledger update, and reservation move happen together or not at all. Every command is idempotent and every state change is reversible only by a compensating record, never by an edit.

4.2 Component model

Figure 3 shows the components and the four trust zones. Table 3 gives, for each component, its purpose, consistency need, main failure modes, and recovery behaviour.

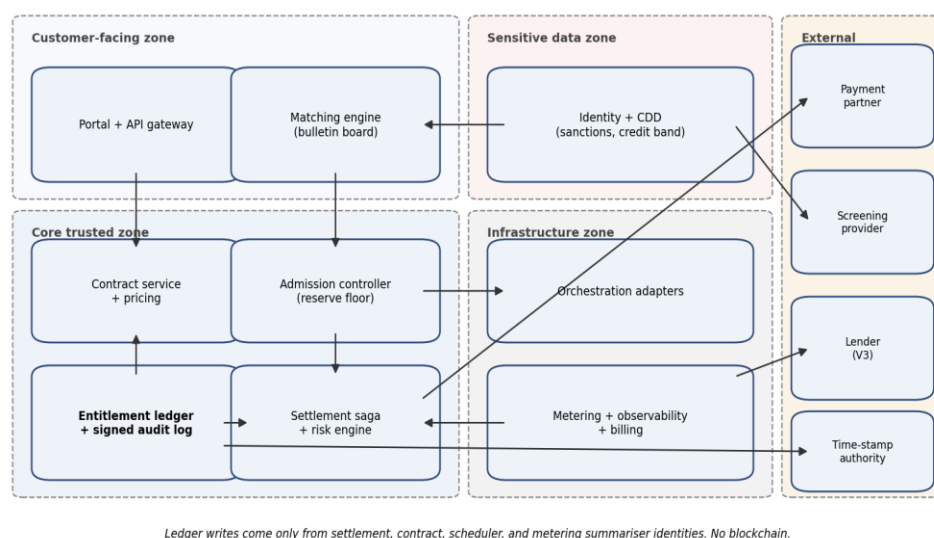


Fig. 3 Reference architecture and trust boundaries

Table 3 Component model

Component	Purpose	Consistency	Main failure modes	Recovery	Owner
Capacity catalogue	Service classes, units, pools, quality attributes	Strong; versioned	Wrong unit definitions	Version rollback; rights reference a catalogue version	Product
Entitlement ledger	System of record for rights and states	Strong (ACID); one writer path; idempotent commands	Lost update; drift from billing	Reconciliation; replay from audit log; point-in-time restore	Engineering
Contract service	Commitments, terms, billing schedules	Strong	Contract–ledger mismatch	Contract is the source for issuance; issuance idempotent by contract ID	Product, Legal
Identity and due diligence	Verification, sanctions screening, credit band	Strong; time-stamped	Stale verification	Re-screen on schedule and at every transfer; suspend on doubt	Compliance
Matching engine	Listings and acceptances (bulletin board)	Eventual for display; strong for match	Double acceptance	Single-writer match; optimistic locking; first confirmed acceptance wins	Engineering
Pricing service	Quotes; validation of asks	Strong	Wrong discount	Versioned price book; signed quotes	Finance, Product
Admission controller	Capacity check; reserve floor	Strong; serialised per pool	Race conditions; reserve miscount	Per-pool lock; recompute from orchestration inventory	SRE
Orchestration adapters	Reserve, move, release capacity; provision on redemption	Idempotent with correlation IDs	Partial or orphaned reservation	Compensating release; reconciliation	SRE
Metering	Usage per entitlement per period	At-least-once with deduplication	Gaps; tampering	Signed records with sequence numbers; re-derivation from raw telemetry	SRE
Billing	Invoices and credits	Strong	Invoice–ledger drift	Monthly three-way reconciliation	Finance
Settlement service	Coordinate payment, ledger transfer, reservation move	Transactional saga with compensation	Payment confirmed but ledger fails, or the reverse	Saga rollback; manual queue for stuck sagas	Engineering, Finance
Audit log	Signed, hash-chained record	Immutable	Key compromise;	WORM storage; external time-	Security

Component	Purpose	Consistency	Main failure modes	Recovery	Owner
	of every state change		tampering	stamps; daily verification	
Risk engine	Concentration, wash-trade, arrears rules	Eventual (minutes)	False positives block trades	Human review queue; versioned thresholds	Risk
Observability and reporting	SLO monitoring; incident linkage to rights; reports	Eventual	Blind spots; wrong figures	Active probes; reports only from reconciled data	SRE, Finance

4.3 Data flows

Six data flows carry the model. At issuance, the contract service confirms a signature, the admission controller checks every month in the window against capacity less reserve, the ledger creates one entitlement per product per month, the orchestration adapter reserves capacity, billing schedules the invoices, and the audit log records each step. At redemption, metering records consumption per entitlement per period, the ledger moves the entitlement to partially_redeemed or redeemed, and billing reconciles. At transfer, a listing is created, a buyer accepts, both parties are re-screened, the risk engine checks limits, the admission controller checks the buyer's pool position, an approver records the decision, and a settlement saga runs: payment confirmed, ledger transfer written for the seller and a new reserved record for the buyer, reservation moved in orchestration, settlement completed. Any failure after payment confirmation triggers compensation, and a stuck saga goes to a manual queue rather than being left half done. At expiry, the scheduler closes the window, the ledger marks the units expired, orchestration releases capacity, and reporting updates the breakage estimate. Suspension and cancellation carry a reason code and apply the contract's refund rule. In the finance-enabled variant, a financing reference is attached to the commitment; no right is pledged and no lender has a claim on the ledger. Figure 4 shows the transfer and settlement sequence.

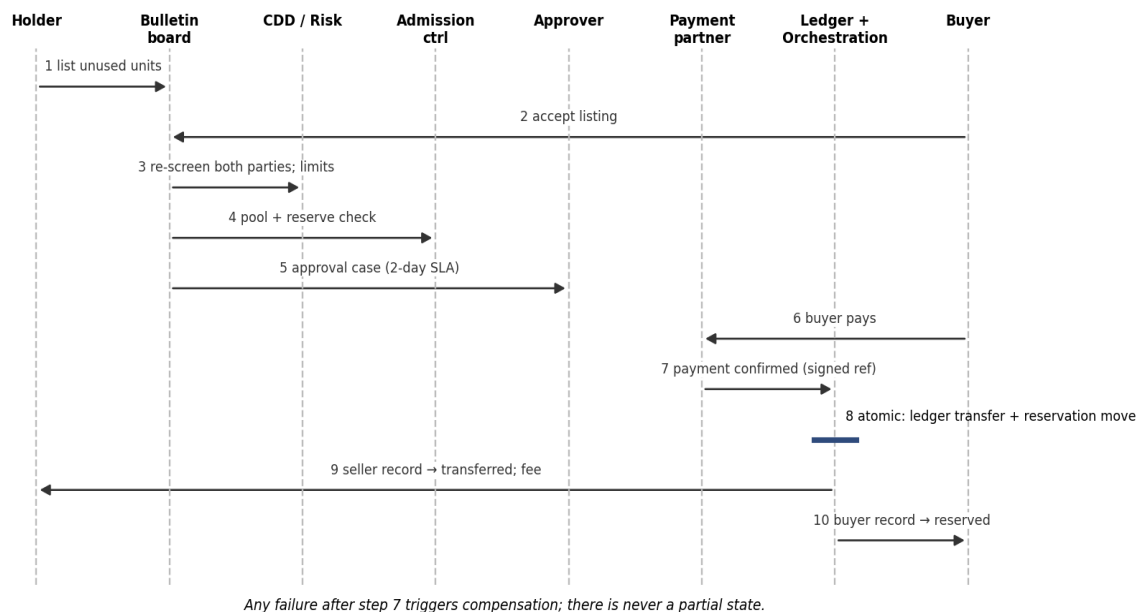


Fig. 4 Permitted transfer and settlement sequence

4.4 Event catalogue

The components communicate through logical events, each with an idempotency key: CommitmentSigned (contract_id); AdmissionDecision (request_id); EntitlementIssued (entitlement_id); CapacityReserved and CapacityReleased (correlation_id); UsageRecorded (entitlement_id, period, sequence); ListingCreated, ListingWithdrawn, ListingExpired (listing_id); MatchCreated (match_id); ScreeningResult (party_id, screened_at); RiskCheckResult (match_id); TransferApproved and TransferRefused (match_id, reason_code); PaymentConfirmed (payment reference); Transferred (transfer_id); SettlementCompleted and SettlementRolledBack (transfer_id); WindowClosed (month); SuspensionApplied, SuspensionLifted, CancellationApplied (entitlement_id, event_time); InvoiceIssued and CreditIssued (invoice_id); IncidentLinked (incident_id); and AuditRecordWritten (record_hash, prev_hash). The names are logical and are mapped to a provider's own systems at implementation.

4.5 Reconciliation and recovery

Reconciliation is the control that makes the rest credible. Every day the ledger's reserved and listed quantities per pool are compared with the orchestration platform's reservations, and every active entitlement is matched to a billing line at the contracted price, with the buyer's line and no duplicate seller line after a transfer. Metering totals are compared with orchestration usage. Any difference above zero units places a hold on the pool that blocks new issuance and transfers until the root cause is found and a compensating record is written. Weekly, the audit log's hash chain is verified end to end. Monthly, the ledger is restored from backup into an isolated environment and rebuilt from the audit log, and the two are compared. Recovery objectives are fifteen minutes of data loss and four hours to restore, with quarterly restore tests. Security controls map to NIST SP 800-53 Rev. 5 families and ISO/IEC 27001:2022 [52, 53].

4.6 Why not a distributed ledger

We considered a distributed ledger and rejected it. The requirements are provider approval before every transfer, controlled reversibility, confidentiality of customer positions, and recovery under the provider's control. A permissioned conventional ledger with signed, hash-chained records gives tamper evidence without giving up control. A public or consortium chain would add bearer-style transfer, an external dependency, and cryptoasset classification questions [54, 55, 56], and would meet no requirement that the conventional design fails.

4.7 Non-functional requirements and scale

Table 10 lists the non-functional requirements. The ledger's size grows with the number of committed contracts times the number of months in their windows, because the design issues one entitlement per product per month rather than one per contract. In the ledger simulation, 300 customers with about 170 committed contracts produced 3,099 entitlements over 24 months, or roughly 130 new entitlement rows a month, and about 30 listings and 15 settled transfers a month. A provider with 10,000 customers at the same mix would create around 4,000 entitlement rows a month and would handle around 1,000 listings and 500 settlements a month, which is a small load for a relational store. The bottlenecks are elsewhere: the admission controller serialises decisions per pool, so pools should be defined narrowly enough that contention stays low; the approval workflow is bounded by human reviewers in V1 and V2, which is why the two-business-day service level and the daily batch are part of the design; and the settlement saga's throughput is bounded by the payment partner's confirmation latency. Monthly windows keep the number of state transitions per right small; a move to daily windows would multiply ledger rows by thirty and is deliberately excluded from the initial design.

Table 10 Non-functional requirements

Area	Requirement
Consistency	Ledger transitions serialisable per entitlement; admission decisions serialised per pool
Idempotency	Every command carries an idempotency key; replays return the original result

Area	Requirement
Auditability	Every state change written to a hash-chained, signed log; daily verification; weekly external time-stamp
Reversibility	Reversals are compensating records within a 24-hour window for technical failure only; no in-place edits
Availability	Ledger and admission controller 99.95% monthly; matching engine may degrade to read-only
Recovery	RPO $\leq$ 15 minutes; RTO $\leq$ 4 hours; quarterly restore test; ledger rebuildable from the audit log
Reconciliation	Daily three-way (ledger, orchestration, billing); any mismatch holds the affected pool
Security	Role separation between approval, settlement, and ledger administration; MFA for operators; keys in an HSM
Privacy	Personal data limited to verification and contacts; pseudonymous identifiers in the ledger; DPIA before pilot
Performance	Approval within two business days; settlement saga completes within one minute of payment confirmation
Change control	Catalogue, price book, market rules, and risk thresholds versioned; changes reopen the compliance register

5 MARKET MECHANISM, ADMISSION CONTROL, AND PRICING

5.1 Product catalogue

Table 4 lists the product units. A product may be sold as a capacity right only if its unit is measured automatically, two units in the same class are interchangeable for the provider's scheduler, its licensing permits a change of user, its cost to serve is known per unit, and at least twenty customers use the class. Bespoke managed services fail these tests and stay on ordinary contracts. Disaster-recovery reservation is a product but is not transferable in the initial deployment, because its demand is correlated across customers in a regional event. Quality attributes follow the structure of ISO/IEC 19086-1 for cloud service level agreements [57].

Table 4 Product-unit specification (extract)

Product	Unit	Quality (measurable)	Minimum lot	Transfer eligible
Compute-Std	1 vCPU-equivalent of a stated CPU generation + 4 GB RAM per month	99.9% monthly availability; CPU steal < 5%	4	Yes (V2+)
Compute-Perf	Same, dedicated cores	99.95%; no steal	8	Yes (V2+)
Storage-Block	100 GB-month at a stated IOPS class	99.9%; IOPS floor	5	Yes (V2+)
Storage-Object	1 TB-month	99.9%; stated durability	1	Yes (V2+)

Product	Unit	Quality (measurable)	Minimum lot	Transfer eligible
Backup	1 TB-month protected with stated retention	Restore-time objective	1	Limited
DR-Reserve	1 vCPU-equivalent reserved at a secondary site per month	Failover time; tested quarterly	8	No initially
Bandwidth	1 Mbps-month committed (95th percentile)	Loss and latency objectives	10	Yes (V2+)
Managed-App	1 managed instance of a named stack per month	Availability and patch objectives	1	Only if standard

5.2 Mechanism choice and rules

We compared bilateral provider-approved transfer, a bulletin board, periodic auctions, a continuous order book, and a provider market-maker. The least complex viable mechanism is a bulletin board: verified holders post asks; verified buyers accept or not; the provider approves before settlement; there are no bids and no displayed order book. This keeps price formation simple and avoids anything that could be seen as a trading venue. A provider market-maker is deferred until after the pilot, because it needs risk limits and an accounting treatment for buybacks.

The rules borrow from the analogues in Table 1. A right cannot be listed until 30 days after issuance and must have at least one full month remaining [24]. No customer may list more than half of its committed units in a month. The ask may not exceed the seller's contracted price, so that resale above list is impossible and no one can present the right as an appreciating asset. Listings last 14 days. Approval has a two-business-day service level and a published list of refusal grounds: sanctions hit, buyer not verified, product incompatibility, licence restriction, failed capacity check, seller in arrears, or a concentration limit breached. No buyer may take more than a quarter of transferred units in a class in a quarter. The transfer fee is 10% of transfer value, paid by the seller at settlement. The provider publishes its reserve policy, approval grounds, fee schedule, and monthly transfer statistics to participants.

Exception handling is part of the rules. If a buyer cannot provision on transferred units because of a technical fault, the provider fixes it within the service level, and if it cannot within 24 hours the transfer is reversed and the fee refunded. If a seller's verification lapses after listing, the listing is suspended and any matched transfer is held. If a capacity incident hits a window, service credits go to whoever holds the right at the time, and the incident is recorded against the entitlement. The provider does not arbitrate payment disputes; the ledger reflects only confirmed settlements. If the reserve in a pool falls below the floor, new issuance and transfers into that pool pause, existing rights are honoured, and participants are told. If a customer becomes insolvent, its rights are suspended pending contact with the officeholder, any transfer by the officeholder needs the provider's approval, and there is no cash refund.

5.3 Admission control

For every product p , month m , and pool q , the admission controller enforces $\text{committed}(q, m) + \text{request} \leq \text{Cap}(q, m) \times (1 - k_q)$, where k_q is the reserve ratio for the pool. The check runs at issuance for every month in the requested window and at every transfer for the buyer's pool position. Overrides require two approvers, expire in 24 hours, are logged, and appear on the board dashboard. When committed capacity in a pool exceeds the floor for any reason, the controller pauses the class automatically. The reserve ratio is recomputed weekly from a correlated-failover simulation in which a regional event triggers many failovers at once; independent-demand overbooking models do not represent this case [17, 18], so k is set from the smallest value that keeps the simulated breach probability below a pre-declared limit.

The allocation problem can be written as a constrained optimisation. The provider chooses committed units to issue per product and month, which transfers to approve, and how much to sell on demand, to maximise risk-adjusted contribution subject to physical capacity per pool, the reserve floor, redundancy at the secondary site under the worst credible correlated failover event, a utilisation ceiling at which service-level objectives hold, licence counts, region and isolation constraints, and transfer feasibility. A robust formulation replaces demand and failover parameters with uncertainty sets and a budget of uncertainty [58]; a two-stage stochastic formulation issues commitments first and chooses on-demand sales, approvals, and emergency capacity after scenarios are revealed [59]. For a small provider we give a heuristic that accepts commitments in order of contribution per unit until headroom is used, keeps a renewal reserve, batches transfer approvals daily against the checks above, refers to a human any transfer whose buyer had an open on-demand quote in the same month, and recomputes k weekly. We make no claim of optimality for it.

5.4 Pricing

Let P_0 be the ordinary monthly price per unit, d the commitment discount, and f the flexibility premium. The fixed commitment price is $P_0(1 - d)$. The transferable price is $P_0(1 - d)(1 + f)$. A transfer of Q units at price p yields transfer value $V = q p Q$, where q is a quality-adjustment factor fixed at 1 because substitution is not allowed, and the fee is τV . A customer's effective cost per used unit is the total paid less transfer recoveries divided by units used. A customer gains from committing only when realised utilisation is high enough that this effective cost falls below P_0 ; transfer recoveries lower the utilisation at which that happens.

6 EVALUATION

6.1 Method

The evaluation is model-based. We built a portfolio simulation of the provider's economics and a lifecycle simulation of the entitlement ledger, both in Python with a fixed random seed (20240930) so that every figure in this section can be reproduced exactly. Parameter values were set by the author and are listed in full in Table 5 and in the supplementary code; a provider applying the model replaces them with its own cost accounting and measured behaviour.

The economic model simulates 400 customers over 24 months. Each customer has a log-autoregressive demand path around 75% of its commitment. Ordinary customers pay P_0 for what they use and churn at 3.5% a month. Committed customers pay the commitment price for C units regardless of use and leave only by default. Under the transferable offer, a holder lists half of its unused units; a fixed share is matched; the buyer uses them; the provider takes the fee; and a share of transferred units, the cannibalisation share, displaces a sale the provider would otherwise have made at P_0 . Costs are a fixed cost per provisioned unit-month (hardware depreciation, licences, data-centre and network, security) of 43, a variable cost per used unit-month (energy, support, backup) of 15, a handling cost per transfer event, a platform cost per committed unit-month, and default losses on unpaid invoices. Capacity is provisioned at $C(1 + k)$ with $k = 0.15$. Each offer is a blended portfolio: a share of customers accepts the commitment and the rest stay on ordinary terms. Common random numbers are used across offers so that differences are not simulation noise. Default loss is counted as two months of unpaid invoices at the loss-given-default rate, because revenue after default is already zero in the simulation. The model omits taxes, working capital, and financing of hardware beyond depreciation, and treats capacity released by churned ordinary customers as redeployable at no cost.

Table 5 Model parameters (base scenario)

Symbol	Meaning	Value
P_0	Ordinary monthly price per unit (index)	100
C, T	Committed units; term (months)	100; 24
d, f, τ	Commitment discount; flexibility premium; transfer fee	0.20; 0.05; 0.10

Symbol	Meaning	Value
u	Mean utilisation of committed units	0.75
σ, ρ	Demand log-volatility; persistence	0.25; 0.85
k, q	Reserve ratio; quality adjustment	0.15; 1.0
c_fix, c_var	Fixed cost per provisioned unit-month; variable cost per used unit-month	43; 15
c_transfer, c_platform	Handling cost per transfer event; platform cost per committed unit-month	40; 1.5
ho, pd, lgd	Monthly churn (ordinary); annual default; loss given default	0.035; 0.03; 0.60
r, r_fin, ref_fee	Provider cost of capital; financing rate; referral fee	0.10; 0.12; 0.02
m, legacy_ratio	Migration cost (months of committed spend); legacy cost / cloud cost	6; 1.15
transfer_share, match_rate, cannibal, transfer_price	Listing propensity; match rate; cannibalisation share; transfer price as share of committed price	0.50; 0.60; 0.50; 0.85
uptake (fixed, transferable, finance)	Share of customers accepting each offer	0.30; 0.45; 0.55
N	Customers	400

The ledger simulation generates a population of 300 customers in three size segments and three risk bands, 300 contracts (monthly, fixed, and transferable), one entitlement per committed contract per live month, listings, transfers, redemptions, capacity by product and month, incidents, invoices, and financing deals, and runs the state machine of Section 3.3 and the rules of Section 5 over 24 months. Ten integrity tests check referential integrity, that no entitlement is transferred twice, that buyers are verified, that transferred quantity never exceeds unused quantity, that commitments never exceed capacity less reserve, and that fees equal price times quantity times rate.

6.2 Scenario results

Table 6 gives the results of the economic model. In the base scenario the transferable offer and the fixed offer produce almost the same contribution NPV (10.95 million against 10.98 million index units). They get there by different routes. Under the transferable offer more customers commit, the coefficient of variation of monthly revenue falls from 0.149 to 0.110, utilisation rises from 0.646 to 0.678, and the customer's cost per used unit falls from 102.9 to 98.0, below the ordinary price of 100. The provider gives up 1.63 million to cannibalisation and pays platform and handling costs, and recovers the amount through uptake and fees. H2 and H4 hold in the model, and H5 sits on a knife edge.

Table 6 Scenario outcomes (contribution NPV in millions of index units over 24 months)

Scenario	Offer	Commit share	Contrib. margin	Contrib. NPV	Revenue CV	Utilisation	Cust. cost per used unit	Retention 12m
Base	Ordinary	1.00	0.194	9.02	0.238	0.656	100.0	0.708
Base	Fixed	0.30	0.207	10.98	0.149	0.646	102.9	0.788
Base	Transferable	0.45	0.188	10.95	0.110	0.678	98.0	0.828

Scenario	Offer	Commit share	Contrib. margin	Contrib. NPV	Revenue CV	Utilisation	Cust. cost per used unit	Retention 12m
Base	Finance	0.55	0.190	11.58	0.088	0.682	116.5	0.855
Upside	Fixed	0.30	0.247	14.12	0.154	0.722	99.1	0.790
Upside	Transferable	0.55	0.220	13.97	0.093	0.750	93.4	0.859
Downside	Fixed	0.30	0.153	7.44	0.147	0.562	108.4	0.784
Downside	Transferable	0.35	0.138	7.05	0.132	0.586	104.9	0.797
Stress	Fixed	0.30	0.076	3.30	0.153	0.468	116.4	0.775
Stress	Transferable	0.32	0.061	2.77	0.146	0.485	113.2	0.779
Reverse stress	Fixed	0.30	0.015	0.63	0.163	0.417	121.1	0.763
Reverse stress	Transferable	0.30	-0.022	-0.84	0.163	0.428	116.3	0.763

Scenario settings: upside raises utilisation to 0.85, match rate to 0.75, and uptake, and lowers cannibalisation to 0.35 and default to 2%; downside lowers utilisation to 0.65 and match rate to 0.40 and raises cannibalisation to 0.65 and default to 5%; stress sets utilisation 0.55, match rate 0.25, cannibalisation 0.80, default 10%; reverse stress sets utilisation 0.50, match rate 0.15, cannibalisation 0.95, default 15%, and no flexibility premium.

The finance-enabled offer has the highest NPV because its uptake is highest, but the customer's all-in cost per used unit rises to 116.5 once instalments are included, and migration payback stretches to 63 months at a 12% financing rate when legacy costs are 15% above cloud. Under these parameters migration finance is a weak product for the customer; H6 cannot be settled by the model and is left to the pilot.

In the downside and stress scenarios the fixed offer beats the transferable offer, because low match rates and high cannibalisation remove the transferable offer's upside while its platform and handling costs remain. In the reverse-stress scenario the transferable offer turns negative while the fixed offer stays marginally positive. That is the combination a pilot must detect early: a thin market, a premium the market will not pay, and buyers who would have paid list price anyway.

Breakage is not an input to the model; it emerges as the share of committed unit-months neither used nor transferred. In the base scenario it is about 27% under the fixed offer and about 20% under the transferable offer, because demand averages 75% of commitment and only some of the slack is transferred. It is the single quantity a provider most needs to measure before pricing.

6.3 Sensitivity and break-even

Figure 5 shows the one-at-a-time sensitivity of the gap between the transferable and fixed offers and the break-even map. The flexibility premium has the largest effect, followed by cannibalisation, match rate, uptake, and platform cost. Two results stand out. A higher match rate reduces the provider's gain at the base cannibalisation of 50%: liquidity helps customers, but every matched unit that displaces a list-price sale costs the provider. And the transfer fee matters far less than the premium; the provider is paid for the option, not for the trade. The break-even line runs from a premium of about 2% at 20% cannibalisation to about 10% at full cannibalisation, so the required premium rises about one percentage point for every ten points of cannibalisation. Table 7 gives the break-even map.

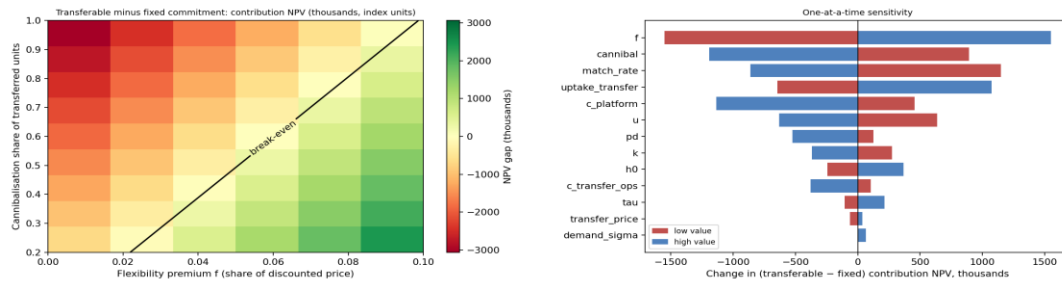


Fig. 5 Break-even map of flexibility premium against cannibalisation (left) and one-at-a-time sensitivity of the transferable-minus-fixed contribution gap (right)

Table 7 Transferable minus fixed contribution NPV (millions) by cannibalisation share and flexibility premium

Cannibalisation	f = 0.00	0.02	0.04	0.06	0.08	0.10
0.2	-0.68	-0.06	0.56	1.18	1.80	2.42
0.4	-1.28	-0.65	-0.03	0.59	1.21	1.83
0.6	-1.87	-1.25	-0.63	-0.01	0.61	1.23
0.8	-2.47	-1.85	-1.23	-0.60	0.02	0.64
1.0	-3.06	-2.44	-1.82	-1.20	-0.58	0.04

6.4 Ledger simulation results

All ten integrity tests pass. The 300-customer population produced 3,099 entitlements, 677 listings, and 361 settled transfers over 24 months. The transfer funnel ran from 677 listings to 412 matches (61%), 368 approvals (54%), and 361 settlements (53%); the difference between approvals and settlements is the seven approved transfers whose settlement failed and was rolled back. Median approval time was 19 hours with a 90th percentile of 45 hours, within the two-business-day service level. Transfer prices averaged 81% of the contracted price with a standard deviation of 9 points, inside the price bounds. Monthly revenue coefficients of variation over months 6 to 23 were 0.168 for monthly contracts, 0.141 for fixed commitments, and 0.101 for transferable commitments; net revenue retention at twelve months was 0.62, 0.79, and 0.79; and Kaplan–Meier survival at twelve months was 0.59, 0.89, and 0.90. Headroom never fell below the reserve floor in any pool, so admission control was never breached; 32 incidents produced one service-level breach; 0.6% of billed amounts were written off; and 3 of 42 financing deals defaulted. Figure 6 shows the retention curves, monthly billing by contract type, and the transfer funnel. These results confirm that the state machine, the admission rules, and the settlement saga behave as specified under a realistic transaction load, and they show the form that a pilot dashboard takes.



Fig. 6 Ledger simulation: retention by contract type (left), monthly billing by contract type (centre), transfer funnel (right)

7 SECURITY ANALYSIS

We applied STRIDE categories to each component [60], mapped adversary techniques to MITRE ATT&CK v15 [61], and mapped controls to NIST SP 800-53 Rev. 5, the NIST Cybersecurity Framework 2.0, ISO/IEC 27001:2022, OWASP ASVS 4.0.3, and the Cloud Security Alliance Cloud Controls Matrix v4 [52, 62, 53, 63, 64]. Table 8 gives an extract of the seventeen threats and thirty-two controls; ratings are on a 1–5 scale.

Table 8 Threat and control matrix (extract)

Threat	Likelihood	Impact	Key controls	Residual
Account takeover leading to transfer	3	4	MFA; step-up and out-of-band confirmation for transfers; new-device anomaly alerts	2
Double transfer or replayed settlement	3	4	Optimistic locking; single-writer match; settlement saga with idempotency keys	1
Capacity overselling	3	5	Admission controller as only issuance path; two-person time-limited overrides; automatic class pause below reserve floor	2
Settlement fraud (fake payment confirmation)	2	5	Mutually authenticated partner channel; unique references; reconciliation to partner statements	1
Ransomware on ledger and backups	3	5	Segmentation; immutable offline backups; monthly rebuild from audit log	2
Meter tampering	2	4	Signed usage records with sequence numbers; monthly re-derivation from raw telemetry	2
Adverse selection through transfers	3	3	Beneficial-ownership linkage; wash-trade and arrears rules; credit-band gating for buyers	2
Correlated DR demand above reserve	2	5	DR-Reserve not transferable; correlated-failover simulation sets k	3
Rights marketed as an investment	2	4	Approved-language list; content audit; complaint monitoring	1

Five abuse cases shaped the controls. In the first, a new customer commits, lists at the floor price to a colluding account, and stops paying; the 30-day holding period, the bar on listing with unpaid invoices, and beneficial-ownership linkage address it. In the second, two related companies list and accept each other's rights every month to make the board look active or to shift cost between entities; ownership linkage, wash-trade detection, and the fee address it. In the third, a capacity planner overrides the admission controller to hit a sales target and a disaster-recovery event then finds no reserve; overrides need two approvers, expire in 24 hours, are logged, and appear on the board dashboard, and the reserve floor pauses the class automatically. In the fourth, an attacker replays a payment confirmation; signed partner messages with unique references and the saga's own idempotency key address it. In the fifth, a salesperson tells a prospect that the rights can be sold later at a profit; an approved-language list, a content audit, and complaint monitoring address it. Financial and infrastructure incidents are joined in one response model with six playbooks, covering account takeover with transfer, ledger–orchestration mismatch, reserve-floor breach, ransomware, settlement fraud, and investment-framing complaints. The security test plan includes a concurrency test of 100 simultaneous

acceptances on one listing (exactly one must match), fault injection in the settlement saga, an admission-override test, a correlated-failover simulation before customer transfers begin, and quarterly restore-and-rebuild tests.

8 COMPLIANCE AND ACCOUNTING CONSIDERATIONS

This section identifies the questions a provider must put to counsel, its auditor, and its tax adviser; it does not answer them. The UK is the core jurisdiction; EU and US notes are comparative. Table 9 gives the register.

Table 9 Regulatory and accounting issue register (extract; UK core)

Issue	Question	Authority	Design mitigation
Payment services	Is a right a payment instrument, or the transfer facility a payment service? Does the limited-network exclusion apply?	PSRs 2017, Sch 1 Pt 2 para 2(k) [47]; FCA PERG 15 [65]; FCA LNE guidance [66]	Provider never holds or transmits buyer funds; no cash redemption; monitor the €1m notification threshold
Electronic money	Could prepaid balances be e-money?	EMRs 2011, reg 2 [48]	Denominate in service units; acceptance only by the issuer
Consumer credit and lending	Is financing a regulated credit agreement, or arranging it a regulated activity?	CCA 1974 [67]; FSMA 2000 s 19 [49]; RAO 2001 [50]	Bodies corporate only; permitted lender; provider role limited
Securities or collective investment	Could a right be a specified investment or an investment contract?	FSMA 2000 s 235; RAO arts 76, 77, 81; comparative: Howey [68]; SEC framework [69]	No yield, no appreciation, resale capped at issue price, consumptive use, provider approval
Cryptoasset regime	Does a ledger-based right fall under cryptoasset rules?	FCA PS19/22 [54]; HM Treasury 2023 [55]; MiCA [56]	Conventional database; no DLT; no wallets
Anti-money laundering and sanctions	Proportionate due diligence for value transfers between customers	MLR 2017 [70]; SAMLA 2018 [71]	Verified customers; screening at each transfer; limits
Assignment, set-off, insolvency	How is a transfer documented; what happens on insolvency?	LPA 1925 s 136 [72]; Insolvency Act 1986 [73]; Insolvency Rules 2016 r 14.25 [74]	Novation or assignment with consent and notice; contractual insolvency terms
Competition and unfair terms	Are transfer restrictions or standard terms objectionable?	Competition Act 1998 [75]; UCTA 1977 s 3 [76]; Ofcom [5]; CMA [6]	Objective refusal grounds; no exclusivity; exit and portability terms
VAT	Is a right a voucher; single- or multi-purpose?	VATA 1994 Sch 10B [51]; Council Directive (EU) 2016/1065 [77]	Tax adviser opinion before first transfer
Operational resilience and critical third parties	Regulated customers must map the dependency; the provider could be designated	FCA PS21/3 [36]; PRA SS2/21 [37]; FSMA 2023 [38]; CP26/23 [39]	Exit plans, audit rights, capacity assurance reports
Data protection	Personal data in verification and transfers	DPA 2018 and UK GDPR [78]	Data minimisation; DPIA; pseudonymous ledger identifiers

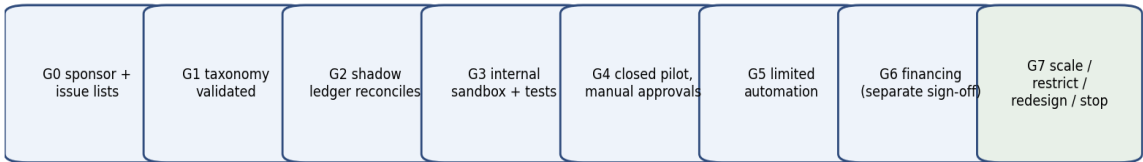
In the EU, the same structure appears in PSD2, the second E-Money Directive, MiCA, DORA, the Data Act’s switching chapter, and NIS2 [79, 80, 56, 40, 20, 41], and MiFID II lists the financial instruments that a physically settled service right with a verified end user does not fall within [81]. In the US, the investment-contract test and the family-resemblance test for notes, the SEC staff framework for digital assets, FinCEN’s money-transmission and prepaid-access analysis, and UCC Article 9 are the reference points [68, 82, 69, 83, 84]. The Law Commission’s 2023 report and the UK Jurisdiction Taskforce’s 2019 statement are the reference points on the property characterisation of digital rights [85, 86].

On accounting, we use IFRS 15 as primary with ASC 606 as cross-reference [42, 43]. The commitment is a contract with a customer whose performance obligation is a stand-ready series satisfied over time. Payments received before service are contract liabilities. Expected breakage on unredeemed units may be recognised in proportion to the pattern of redemption if the provider is entitled to it, otherwise when exercise becomes remote (IFRS 15 paragraphs B44–B47; ASC 606-10-55-46 to 55-49) [44]. The transfer option may be a material right that requires allocation of part of the price (paragraphs B39–B43). An upfront payment more than a year ahead of delivery may contain a significant financing component (paragraphs 60–65). In a transfer the provider is likely an agent for the transaction between customers and recognises the fee net, while it remains principal for delivery of the service and recognises that revenue gross (paragraphs B34–B38). A transfer is best treated as a novation: the seller’s remaining obligation is derecognised and a new contract with the buyer is recognised at the same price. Receivables carry lifetime expected credit losses under IFRS 9 [87], and onerous contracts fall under IAS 37 [88]. A capacity right over pooled resources is generally not a lease under IFRS 16 paragraph B20 [45, 46]. For tax, timing generally follows the accounting [89], and the VAT voucher rules may apply on issue and on each transfer if a right is a single-purpose voucher [51].

9 PILOT DESIGN AND IMPLEMENTATION TEMPLATE

9.1 Gated pilot

Deployment proceeds through eight gates (Figure 7). Gate 0 names a board sponsor and an accountable owner and opens the counsel and auditor issue lists. Gate 1 validates the capacity taxonomy against metering for three months. Gate 2 requires the shadow ledger to reconcile with billing and orchestration for sixty consecutive days with zero unresolved breaks. Gate 3 is an internal sandbox with employee accounts that passes all security tests, with a data-protection impact assessment and an auditor consultation complete. Gate 4 is a closed customer pilot with manual approvals for three months, with counsel’s opinion on the payments, e-money, securities, and anti-money-laundering questions received. Gate 5 adds limited automated matching under hard limits. Gate 6 tests financing only after separate legal, credit, accounting, and conduct sign-off. Gate 7 decides to scale, restrict, redesign, or terminate against criteria declared before the pilot starts.



Pause at any gate: reserve below floor · unresolved reconciliation break · SLA breach trend · counsel or auditor concern · investment-framing complaint

Fig. 7 Pilot stage-gate roadmap

The pilot uses a closed cohort of verified business customers, sixty in the committed arms (thirty on each offer) and sixty similar customers on monthly terms as a comparison group, with a six-month baseline and twelve months of transfer operation. Operational limits cap committed units in pilot classes at 25% of pool capacity, listed units at 10% of a pool per month, and any buyer at 25% of transferred units per quarter. The key indicators are commitment uptake

and term, gross and net revenue retention, revenue coefficient of variation, utilisation and stranded capacity, listing, match, approval, and settlement rates, approval time, price dispersion, service-level outcomes, support hours per right, measured cannibalisation (buyers who had an open on-demand quote in the same month), perceived lock-in and flexibility from a quarterly survey, complaints and disputes, reconciliation breaks, and reserve headroom. The pilot pauses automatically when reserve headroom falls below the floor, when a reconciliation break stays unresolved for more than 24 hours, when the service-level breach rate exceeds baseline by 20% for two months, or when a complaint alleges investment framing. Safety and service-level criteria cannot be traded against revenue criteria: a pilot with strong economics and one unresolved reserve breach is restricted or terminated, not scaled.

9.2 Implementation template

The template has nine parts: a readiness assessment scoring fifteen capabilities from 0 to 2, of which eight are critical and any zero blocks the pilot; a product-definition worksheet; the financial model inputs of Table 5, to be replaced with the provider's own figures; the control matrix; ten counsel questions and three tax questions; ten named governance roles; the pilot gates and a plain-language customer disclosure that states that a right is a service entitlement, not an investment, not money, and not redeemable for cash; exit procedures for withdrawal of the facility, withdrawal of the product, customer exit at term end, and termination by gate decision; and a decision rubric with four outcomes: proceed to shadow testing, proceed with restrictions, redesign, or reject. A provider should reject the model if it cannot measure capacity to the unit level, cannot reconcile a shadow ledger against orchestration and billing, cannot refuse a transfer on objective grounds, cannot get comfortable with counsel on the payments and securities perimeters, finds the break-even premium above what its customers will pay, or finds that the correlated-failover simulation cannot meet the service-level objective at an affordable reserve.

10 DISCUSSION

Four findings hold within the limits of the evidence and the model. First, the model's value to the provider comes from uptake and steadier revenue, not from transfer fees. If transferability does not raise commitment uptake, the transfer facility is a cost. Second, liquidity is not free. The same matches that make customers better off displace list-price sales, and the premium needed to offset that rises roughly one point for every ten points of cannibalisation. A provider that cannot measure cannibalisation cannot price the premium. Third, the physical constraints dominate. The correlated demand of disaster-recovery failover is the risk that the cloud overbooking literature does not cover, and it is why DR reservation stays out of the transfer facility and why the reserve ratio must come from a correlated simulation rather than an independent no-show model. Fourth, the legal design is a set of exclusions that must be preserved: no cash-out, no yield, no resale above issue price, no anonymous holders, provider approval before every settlement, and a conventional ledger. Each exclusion maps to a perimeter question in Table 9; relaxing any one of them reopens the analysis.

Read against Roth's tests [33], the design makes three choices. For thickness, it limits the products to a few standard classes that at least twenty customers already use, so that a listing has a real chance of a buyer; the failed exchanges show that breadth without depth is fatal [21, 22]. For congestion, it uses a bulletin board with fixed listing life and a two-day approval clock rather than an order book. For safety, it verifies every participant, bounds prices so that nobody can overpay above list or profit by reselling above it, and settles atomically so that nobody is left holding a right the platform cannot deliver. Akerlof's problem [34] is present in a specific form: a customer who lists rights may be one whose business is shrinking. The design cannot remove that, but credit-band gating and the concentration limit stop the market from becoming a route for distressed customers to pass losses to weaker buyers. The two-sided pricing point of Rochet and Tirole [32] also applies: the provider charges the seller the fee and every committed customer the premium, and does not charge buyers, because the buyer's willingness to take a shorter, discounted right is what makes the market clear.

Hypothesis H7 says complexity rises faster than linearly as rights become finer. The design accepts this and keeps rights coarse: monthly windows, minimum lots, one region, no substitution, and a small catalogue. The sensitivity

analysis shows that platform cost alone can move the transferable offer from break-even to a loss, and the pilot measures support hours per right so that H7 can be tested before any move toward finer rights. The financing variant is the weakest part of the framework. Its economics depend on the gap between legacy and cloud cost, which the pilot must measure, and the empirical record on revenue-based finance shows adverse selection among takers [31]. The design therefore keeps lending with a permitted lender, restricts borrowers to bodies corporate, and tests financing last.

Three limitations apply. The framework has been evaluated by simulation and analysis; it has not yet been validated with operational data from a live deployment, and the pilot protocol in Section 9 exists to provide that validation. The legal analysis is UK-centred issue spotting, not advice, and its classifications depend on facts a real provider must supply. The economic model omits taxes, working capital, and hardware financing beyond depreciation, and its parameter values are the author's; a provider must replace them with its own cost accounting and measured behaviour before drawing conclusions. Future work should report a pilot run under the protocol, calibrate the correlated-failover simulation to a provider's incident history, and compare the bulletin board with a provider market-maker under risk limits once transfer data exist.

11 CONCLUSION

Transferable cloud capacity rights are a plausible way for a managed hosting provider to obtain longer commitments and steadier revenue while giving customers a way out of capacity they cannot use. The design that keeps the risks in view is narrow: business customers only, a closed loop, rights in service units with no cash-out and no yield, transfers only among verified customers with provider approval before settlement, an admission controller and a reserve floor above any matching, and a conventional, signed entitlement ledger. In simulation, such a design matches a fixed commitment on provider contribution while lowering revenue variation and raising utilisation, provided the flexibility premium covers the cannibalisation that liquidity brings. Migration finance is the least supported part and should be tested last. The paper contributes the architecture, the market rules, the economics, the security and compliance analysis, and a pilot with rules for stopping, so that a provider can test the model and, if the evidence says so, reject it.

DECLARATIONS

Availability of data and materials. The economic model (`economics_model.py`), the ledger simulation (`ledger_simulation.py`), the generated tables, the figure generator, and the evidence table with source dates are available from the author on request and will be deposited in a public repository on acceptance. Both scripts are deterministic for seed 20240930.

Competing interests. The author is employed by Microsoft, a provider of cloud services. This work was conducted independently of that employment; the views expressed are the author's own and do not represent those of Microsoft.

Funding. No external funding was received for this work.

Author's contributions. RJ conceived the study, designed the architecture and market mechanism, built the models, analysed the results, and wrote the manuscript.

Ethics approval and consent to participate. Not applicable. No human participants took part.

Acknowledgements. The author acknowledges the use of an AI research assistant for evidence collation, model implementation support, and drafting under the author's supervision; all sources were verified by the author.

REFERENCES

- [1] Vogels W (2012) Expanding flexibility – introducing the Reserved Instance Marketplace. All Things Distributed, 12 September 2012. <https://www.allthingsdistributed.com/2012/09/reserved-instance-marketplace.html>

- [2] Amazon Web Services (2012) Announcing Amazon EC2 Reserved Instance Marketplace. AWS What's New, 12 September 2012. <https://aws.amazon.com/about-aws/whats-new/2012/09/12/announcing-amazon-ec2-reserved-instance-marketplace>
- [3] Microsoft (2019) Self-service exchange and refund for Azure Reservations. Azure Blog, 2 April 2019. <https://azure.microsoft.com/en-us/blog/self-service-exchange-and-refund-for-azure-reservations/>
- [4] Amazon Web Services (2019) Introducing Savings Plans. AWS What's New, 6 November 2019. <https://aws.amazon.com/about-aws/whats-new/2019/11/introducing-savings-plans>
- [5] Ofcom (2023) Cloud services market study: final report. 5 October 2023. <https://www.ofcom.org.uk/siteassets/resources/documents/consultations/category-3-4-weeks/244808-cloud-services-market-study/associated-documents/cloud-services-market-study-final-report.pdf>
- [6] Competition and Markets Authority (2024) Cloud services market investigation: committed spend agreements working paper. 23 May 2024. https://assets.publishing.service.gov.uk/media/664f0300f34f9b5a56adccfd/Committed_spend_agreements_working_paper.pdf
- [7] Hevner AR, March ST, Park J, Ram S (2004) Design science in information systems research. MIS Q 28(1):75–105. <https://doi.org/10.2307/25148625>
- [8] Peffers K, Tuunanen T, Rothenberger MA, Chatterjee S (2007) A design science research methodology for information systems research. J Manag Inf Syst 24(3):45–77. <https://doi.org/10.2753/MIS0742-1222240302>
- [9] Wu C, Buyya R, Ramamohanarao K (2019) Cloud pricing models: taxonomy, survey, and interdisciplinary challenges. ACM Comput Surv 52(6):108. <https://doi.org/10.1145/3342103>
- [10] Kilcioglu C, Rao JM, Kannan A, McAfee RP (2017) Usage patterns and the economics of the public cloud. In: Proceedings of the 26th International Conference on World Wide Web (WWW '17), pp 83–91. <https://doi.org/10.1145/3038912.3052707>
- [11] Ben-Yehuda OA, Ben-Yehuda M, Schuster A, Tsafirir D (2013) Deconstructing Amazon EC2 spot instance pricing. ACM Trans Econ Comput 1(3):16. <https://doi.org/10.1145/2509413.2509416>
- [12] Dierks L, Seuken S (2022) Cloud pricing: the spot market strikes back. Manag Sci 68(1):105–122. <https://doi.org/10.1287/mnsc.2020.3907>
- [13] Toosi AN, Vanmechelen K, Ramamohanarao K, Buyya R (2015) Revenue maximization with optimal capacity control in infrastructure as a service cloud markets. IEEE Trans Cloud Comput 3(3):261–274. <https://ieeexplore.ieee.org/document/6987322/>
- [14] Nunez MA, Bai X, Du L (2021) Leveraging slack capacity in IaaS contract cloud services. Prod Oper Manag 30(4):883–901. <https://doi.org/10.1111/poms.13283>
- [15] Rogers O, Cliff D (2012) A financial brokerage model for cloud computing. J Cloud Comput 1:2. <https://doi.org/10.1186/2192-113X-1-2>
- [16] Cartlidge J, Clamp P (2014) Correcting a financial brokerage model for cloud computing: closing the window of opportunity for commercialisation. J Cloud Comput 3:2. <https://doi.org/10.1186/2192-113X-3-2>
- [17] Cohen MC, Keller PW, Mirrokni V, Zadimoghaddam M (2019) Overcommitment in cloud services: bin packing with chance constraints. Manag Sci 65(7):3255–3271. <https://doi.org/10.1287/mnsc.2018.3091>
- [18] Tomás L, Tordsson J (2014) An autonomic approach to risk-aware data center overbooking. IEEE Trans Cloud Comput 2(3):292–305. <https://ieeexplore.ieee.org/document/6819458/>

- [19] Opara-Martins J, Sahandi R, Tian F (2016) Critical analysis of vendor lock-in and its impact on cloud computing migration: a business perspective. *J Cloud Comput* 5:4. <https://doi.org/10.1186/s13677-016-0054-z>
- [20] European Parliament and Council (2023) Regulation (EU) 2023/2854 of 13 December 2023 on harmonised rules on fair access to and use of data (Data Act). *OJ L*, 22.12.2023. <http://data.europa.eu/eli/reg/2023/2854/oj>
- [21] heise online (2016) Deutsche Börse Cloud Exchange macht dicht. February 2016. <https://www.heise.de/news/Deutsche-Boerse-Cloud-Exchange-macht-dicht-3098846.html>
- [22] Ferreira P, Mindel J, McKnight L (2003) Why have bandwidth trading markets not matured? Analysis of technological and market issues. *Int J Technol Policy Manag* 3(2):142–160. <https://doi.org/10.1504/IJTPM.2003.003886>
- [23] Schwartz A (2003) Enron's missed opportunity: Enron's refusal to build a collaborative market turned bandwidth trading into a disaster. *BRIE Working Paper* 152, University of California, Berkeley. <https://escholarship.org/uc/item/ok61f1nb>
- [24] The Crystal Clouds (2012) Amazon EC2 Reserved Instance Marketplace (reproduction of AWS launch terms). 14 September 2012. <http://thecrystalclouds.blogspot.com/2012/09/amazon-ec2-reserved-instance-marketplace.html>
- [25] Cramton P, Ockenfels A, Stoft S (2013) Capacity market fundamentals. *Econ Energy Environ Policy* 2(2):27–46. <https://doi.org/10.5547/2160-5890.2.2.2>
- [26] The Electricity Capacity Regulations 2014, SI 2014/2043 (UK). <https://www.legislation.gov.uk/uksi/2014/2043>
- [27] Belobaba PP (1989) Application of a probabilistic decision model to airline seat inventory control. *Oper Res* 37(2):183–197. <https://doi.org/10.1287/opre.37.2.183>
- [28] Talluri KT, van Ryzin GJ (2004) The theory and practice of revenue management. Springer, New York. <https://doi.org/10.1007/b139000>
- [29] Klapper L (2006) The role of factoring for financing small and medium enterprises. *J Bank Financ* 30(11):3111–3130. <https://doi.org/10.1016/j.jbankfin.2006.05.001>
- [30] Eisfeldt AL, Rampini AA (2009) Leasing, ability to repossess, and debt capacity. *Rev Financ Stud* 22(4):1621–1657. <https://doi.org/10.1093/rfs/hhn026>
- [31] Russel D, Shi C, Clarke R (2023) Revenue-based financing. Working paper, 20 October 2023. SSRN 4608506. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4608506
- [32] Rochet J-C, Tirole J (2003) Platform competition in two-sided markets. *J Eur Econ Assoc* 1(4):990–1029. <https://doi.org/10.1162/154247603322493212>
- [33] Roth AE (2008) What have we learned from market design? *Econ J* 118(527):285–310. <https://doi.org/10.1111/j.1468-0297.2007.02121.x>
- [34] Akerlof GA (1970) The market for “lemons”: quality uncertainty and the market mechanism. *Q J Econ* 84(3):488–500. <https://doi.org/10.2307/1879431>
- [35] Uptime Institute (2024) Annual outage analysis 2024: executive summary. March 2024. <https://datacenter.uptimeinstitute.com/rs/711-RIA-145/images/2024.Resiliency.Survey.ExecSum.pdf>
- [36] Financial Conduct Authority (2021) PS21/3: Building operational resilience. March 2021. <https://www.fca.org.uk/publications/policy-statements/ps21-3-building-operational-resilience>

- [37] Prudential Regulation Authority (2021) SS2/21: Outsourcing and third party risk management. Bank of England, March 2021
- [38] Financial Services and Markets Act 2023, c. 29 (UK). <https://www.legislation.gov.uk/ukpga/2023/29>
- [39] Bank of England, Prudential Regulation Authority, Financial Conduct Authority (2023) CP26/23: Operational resilience: critical third parties to the UK financial sector. December 2023. <https://www.bankofengland.co.uk/-/media/boe/files/prudential-regulation/consultation-paper/2023/december/cp2623-operational-resilience-critical-third-parties-to-the-uk-financial-sector.pdf>
- [40] European Parliament and Council (2022) Regulation (EU) 2022/2554 of 14 December 2022 on digital operational resilience for the financial sector (DORA). OJ L 333, 27.12.2022. <http://data.europa.eu/eli/reg/2022/2554/oj>
- [41] European Parliament and Council (2022) Directive (EU) 2022/2555 of 14 December 2022 on measures for a high common level of cybersecurity across the Union (NIS 2). OJ L 333, 27.12.2022. <http://data.europa.eu/eli/dir/2022/2555/oj>
- [42] International Accounting Standards Board (2014) IFRS 15 Revenue from Contracts with Customers. IFRS Foundation, London
- [43] Financial Accounting Standards Board (2014) Accounting Standards Update No. 2014-09, Revenue from Contracts with Customers (Topic 606). FASB, Norwalk
- [44] Financial Accounting Standards Board (2016) Accounting Standards Update No. 2016-04, Liabilities—Extinguishments of Liabilities (Subtopic 405-20): Recognition of Breakage for Certain Prepaid Stored-Value Products. FASB, Norwalk
- [45] International Accounting Standards Board (2016) IFRS 16 Leases. IFRS Foundation, London
- [46] IFRS Interpretations Committee (2019) Agenda decision: customer's right to receive access to the supplier's software hosted on the cloud (IFRS 16). IFRIC Update, March 2019. <https://www.ifrs.org/news-and-events/updates/ifric/2019/ifric-update-march-2019/>
- [47] The Payment Services Regulations 2017, SI 2017/752 (UK). <https://www.legislation.gov.uk/uksi/2017/752>
- [48] The Electronic Money Regulations 2011, SI 2011/99 (UK). <https://www.legislation.gov.uk/uksi/2011/99>
- [49] Financial Services and Markets Act 2000, c. 8 (UK). <https://www.legislation.gov.uk/ukpga/2000/8>
- [50] The Financial Services and Markets Act 2000 (Regulated Activities) Order 2001, SI 2001/544 (UK). <https://www.legislation.gov.uk/uksi/2001/544>
- [51] Value Added Tax Act 1994, c. 23, Schedule 10B (UK). <https://www.legislation.gov.uk/ukpga/1994/23/schedule/10B>
- [52] National Institute of Standards and Technology (2020) Security and privacy controls for information systems and organizations. NIST SP 800-53 Rev. 5. <https://doi.org/10.6028/NIST.SP.800-53r5>
- [53] ISO/IEC (2022) ISO/IEC 27001:2022 Information security, cybersecurity and privacy protection — Information security management systems — Requirements. International Organization for Standardization, Geneva
- [54] Financial Conduct Authority (2019) PS19/22: Guidance on cryptoassets. July 2019
- [55] HM Treasury (2023) Future financial services regulatory regime for cryptoassets: response to the consultation and call for evidence. 30 October 2023. <https://www.gov.uk/government/consultations/future-financial-services-regulatory-regime-for-cryptoassets>

- [56] European Parliament and Council (2023) Regulation (EU) 2023/1114 of 31 May 2023 on markets in crypto-assets (MiCA). OJ L 150, 9.6.2023. <http://data.europa.eu/eli/reg/2023/1114/oj>
- [57] ISO/IEC (2016) ISO/IEC 19086-1:2016 Information technology – Cloud computing – Service level agreement (SLA) framework – Part 1: Overview and concepts. International Organization for Standardization, Geneva. <https://www.iso.org/standard/67545.html>
- [58] Bertsimas D, Sim M (2004) The price of robustness. Oper Res 52(1):35–53. <https://doi.org/10.1287/opre.1030.0065>
- [59] Birge JR, Louveaux F (2011) Introduction to stochastic programming, 2nd edn. Springer, New York. <https://doi.org/10.1007/978-1-4614-0237-4>
- [60] Shostack A (2014) Threat modeling: designing for security. Wiley, Indianapolis
- [61] MITRE (2024) ATT&CK v15, Enterprise matrix. April 2024. <https://attack.mitre.org/versions/v15/>
- [62] National Institute of Standards and Technology (2024) The NIST Cybersecurity Framework (CSF) 2.0. NIST CSWP 29, 26 February 2024. <https://doi.org/10.6028/NIST.CSWP.29>
- [63] OWASP Foundation (2021) Application Security Verification Standard 4.0.3. October 2021
- [64] Cloud Security Alliance (2021) Cloud Controls Matrix v4. January 2021
- [65] Financial Conduct Authority. PERG 15: Guidance on the scope of the Payment Services Regulations 2017; PERG 3A: Guidance on the scope of the Electronic Money Regulations 2011. FCA Handbook. <https://handbook.fca.org.uk/handbook/perg15>
- [66] Financial Conduct Authority (2017, updated 2024) Limited Network Exclusion (LNE). First published 19 September 2017, updated 3 May 2024. <https://www.fca.org.uk/firms/limited-network-exclusion>
- [67] Consumer Credit Act 1974, c. 39 (UK). <https://www.legislation.gov.uk/ukpga/1974/39>
- [68] SEC v. W. J. Howey Co., 328 U.S. 293 (1946)
- [69] U.S. Securities and Exchange Commission, Strategic Hub for Innovation and Financial Technology (2019) Framework for “investment contract” analysis of digital assets. 3 April 2019
- [70] The Money Laundering, Terrorist Financing and Transfer of Funds (Information on the Payer) Regulations 2017, SI 2017/692 (UK). <https://www.legislation.gov.uk/uksi/2017/692>
- [71] Sanctions and Anti-Money Laundering Act 2018, c. 13 (UK). <https://www.legislation.gov.uk/ukpga/2018/13>
- [72] Law of Property Act 1925, c. 20, s. 136 (UK). <https://www.legislation.gov.uk/ukpga/Geo5/15-16/20/section/136>
- [73] Insolvency Act 1986, c. 45 (UK). <https://www.legislation.gov.uk/ukpga/1986/45>
- [74] The Insolvency (England and Wales) Rules 2016, SI 2016/1024 (UK). <https://www.legislation.gov.uk/uksi/2016/1024>
- [75] Competition Act 1998, c. 41 (UK). <https://www.legislation.gov.uk/ukpga/1998/41>
- [76] Unfair Contract Terms Act 1977, c. 50 (UK). <https://www.legislation.gov.uk/ukpga/1977/50>
- [77] Council of the European Union (2016) Council Directive (EU) 2016/1065 of 27 June 2016 amending Directive 2006/112/EC as regards the treatment of vouchers. OJ L 177, 1.7.2016. <http://data.europa.eu/eli/dir/2016/1065/oj>
- [78] Data Protection Act 2018, c. 12 (UK), and the UK GDPR. <https://www.legislation.gov.uk/ukpga/2018/12>

- [79] European Parliament and Council (2015) Directive (EU) 2015/2366 of 25 November 2015 on payment services in the internal market (PSD2). OJ L 337, 23.12.2015. <http://data.europa.eu/eli/dir/2015/2366/oj>
- [80] European Parliament and Council (2009) Directive 2009/110/EC of 16 September 2009 on the taking up, pursuit and prudential supervision of the business of electronic money institutions. OJ L 267, 10.10.2009. <http://data.europa.eu/eli/dir/2009/110/oj>
- [81] European Parliament and Council (2014) Directive 2014/65/EU of 15 May 2014 on markets in financial instruments (MiFID II). OJ L 173, 12.6.2014. <http://data.europa.eu/eli/dir/2014/65/oj>
- [82] *Reves v. Ernst & Young*, 494 U.S. 56 (1990)
- [83] Financial Crimes Enforcement Network (2019) Application of FinCEN's regulations to certain business models involving convertible virtual currencies. FIN-2019-G001, 9 May 2019
- [84] Uniform Law Commission (2010) Uniform Commercial Code, Article 9: Secured Transactions (2010 amendments)
- [85] Law Commission (2023) Digital assets: final report. Law Com No 412, HC 1486, 28 June 2023. <https://lawcom.gov.uk/project/digital-assets/>
- [86] UK Jurisdiction Taskforce (2019) Legal statement on cryptoassets and smart contracts. LawTech Delivery Panel, November 2019. https://technation.io/wp-content/uploads/2019/11/6.6056_JO_Cryptocurrencies_Statement_FINAL_WEB_111119-1.pdf
- [87] International Accounting Standards Board (2014) IFRS 9 Financial Instruments. IFRS Foundation, London
- [88] International Accounting Standards Board. IAS 37 Provisions, Contingent Liabilities and Contingent Assets (1998, as amended). IFRS Foundation, London
- [89] Corporation Tax Act 2009, c. 4, s. 46 (UK). <https://www.legislation.gov.uk/ukpga/2009/4/section/46>