



QUANTUM COMPUTING IN DIGITAL CAPITAL MARKETS



Business opportunities beyond security paradigms.
A short thought-leadership paper for ADGM Academy
Cyber-Resilient Behaviour Foundations

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Executive summary

Quantum technologies are usually introduced to financial services through a single lens: cybersecurity. That focus is necessary, but incomplete. This paper argues that the larger strategic question is how quantum computing may relax computational constraints that currently shape market design, risk management, and supervisory practice. The near-term will be hybrid (quantum and classical) and experimental, yet meaningful value can already be created by building 'quantum-ready' capabilities, data foundations, and governance.

FIVE TAKEAWAYS:



Security is the entry point, not the end state: institutions should treat post-quantum cryptography and key-management as an enabling layer, while preparing for performance-driven quantum use cases.



The first credible business benefits are likely to come from optimisation and sampling problems (e.g. portfolio construction, execution scheduling, and scenario generation) where hybrid approaches can reduce time-to-decision.



Mid-horizon value is tied to better risk models: quantum-enhanced simulation and calibration can improve the tractability of complex derivative books and stress-testing, even if the "quantum advantage" is narrow and task-specific.



Longer-term, quantum computing could shift market microstructure by expanding what is economically computable (risk transfer, market making, and systemic-risk analytics), which in turn affects governance and regulatory expectations.



ADGM is well-placed to convene pilots because it combines a mature virtual-asset framework with pioneering institutional infrastructure for digital organisations (e.g. the DLT Foundations regime).

The paper is structured as a short-, mid-, and long-term roadmap for financial institutions and regulators. It closes with a practical agenda that can be executed without waiting for fault-tolerant quantum computers.

1. Quantum computing as a market-structure innovation

Financial markets are computational systems. Prices, risk measures, margin requirements, and supervisory reports are produced by models that translate uncertain information into decisions. For decades, improvements in classical computing expanded what could be calculated fast enough to matter, supporting new products, faster trading, and more granular risk control. Quantum computing, if it matures, is best understood as the next potential step in that continuum: not a replacement for classical IT, but a new class of coprocessor that may make certain problems cheaper or faster to solve.

This perspective matters because computational limits are not just technical; they shape the feasible set of market practices. When a risk measure is too slow to compute, firms simplify. When a stress test is too expensive, scenarios are reduced. When an optimisation is intractable, heuristics substitute for 'best possible' allocation. A shift in computability therefore has structural implications: it changes how markets are intermediated, how liquidity is provisioned, and which control points regulators can rely on.

2. Beyond security: separating quantum risk from quantum opportunity

A realistic quantum strategy begins with a distinction between (i) defensive requirements and (ii) proactive opportunities.

- **Defensive requirements** include migrating cryptography to post-quantum standards, rethinking key management, and developing an inventory of cryptographic dependencies across market infrastructure. For a cross-border financial center, the strategic challenge is less about a single migration date and more about coordinating phased change across many counterparties and systems.
- **Proactive opportunities** include quantum-enhanced optimisation, simulation, and machine learning for tasks that are currently bottlenecked by compute time or combinatorial complexity. In the early years, these opportunities will be narrow, experimental, and hybrid, but they can still be commercially meaningful if they reduce latency in decision cycles (hours to minutes) or unlock higher-fidelity models at the same cost.

In practice, security and opportunity should be governed together. The same governance that manages cryptographic transition (model risk management, validation, third-party assurance, and auditability) also creates the controls needed to trial hybrid quantum workloads responsibly.



3. Short-term (0 to 24 months): hybrid value and quantum readiness

In the short term, the objective is not 'full quantum advantage'. It is to identify business processes where better optimisation or faster sampling creates real value, and to build the organisational capability to run controlled experiments. Three areas are particularly promising.

3.1 Portfolio construction and allocation under real-world constraints

Mean-variance optimisation is a classical textbook problem; the real challenge in practice is constraint-rich allocation. Institutional portfolios must handle transaction costs, turnover limits, concentration caps, liquidity constraints, and regulatory capital considerations. These constraints can turn allocation into a large combinatorial optimisation problem, where fast 'good enough' solutions are valuable, especially when portfolio decisions must be refreshed frequently (e.g. in volatile markets or for systematic strategies).

Hybrid quantum approaches (quantum-inspired or quantum-assisted solvers) are being explored for exactly these constraint-heavy optimisations. A credible near-term goal is not outperforming best-in-class classical solvers across all instances; it is reducing time-to-solution for specific portfolios or enabling higher-fidelity constraint sets without increasing compute budgets.

3.2 Operational optimisation: scheduling, collateral, and treasury

Many high-value optimisation problems sit outside 'quant' teams. Examples include scheduling settlement and funding flows, optimising collateral allocation across CCPs (Central Counterparties) and bilateral relationships, and planning liquidity buffers under regulatory constraints. These problems are often solved with heuristics and manual overlays because the exact optimum is computationally expensive. For a financial center that is scaling digital-asset activity, the ability to optimise operational processes can be as valuable as a new trading signal.

3.3 A quantum-ready experimentation model for institutions

Because early quantum compute is noisy and scarce, the dominant short-term pattern is experimentation in sandboxes and shared testbeds. A robust experimentation model includes:

- Use-case triage: define a small pipeline of problems with measurable KPIs (time-to-solution, solution quality, capital or liquidity impact).
- Data discipline: ensure clean, versioned datasets and reproducible pipelines; hybrid quantum experiments are brittle without this foundation.
- Model governance: apply model risk management from day one (documentation, validation, and independent review).
- Vendor neutrality: design pilots so that results are portable across platforms, avoiding lock-in to a single provider or hardware approach.
- Skills: build a small "translator" team that can speak both quantum and business, often more valuable than hiring many quantum specialists immediately.

For ADGM-based institutions, this experimentation model can be aligned with broader digital market initiatives, including tokenisation, smart-contract-based financial instruments, and embedded compliance controls, so that quantum exploration is integrated with the evolution toward digital capital markets.

4. Mid-term (2 to 5 years): risk, pricing, and supervisory analytics

If short-term value is driven by optimisation, mid-term value is likely to be driven by simulation. Many financial models rely on Monte Carlo methods, calibration loops, and scenario generation. These are compute-hungry, and their cost limits the number of scenarios, paths, and sensitivities that can be considered within operational time windows.

4.1 Derivative pricing, calibration, and hedging

Quantum algorithms for sampling and linear algebra may, over time, accelerate components of pricing and calibration workflows, e.g. generating scenarios, solving high-dimensional systems, or calibrating stochastic models. Even incremental speed-ups can matter if they allow desks to reprice books more frequently, improve hedge quality, or run richer intraday risk.

4.2 Systemic-risk modelling and network stress testing

For regulators and systemically important institutions, a key promise lies in network models of interconnected exposures. Stress tests often simplify networks because exact analysis scales poorly with the number of nodes and contracts. Quantum-enhanced optimisation and sampling could support higher-resolution network analysis, exploring contagion paths, liquidity spirals, and feedback loops across traditional and digital-asset markets.

This matters for digital capital markets because composability and cross-chain linkages can create rapid spillovers. Better analytics can strengthen both supervisory practice and the industry's own risk controls, especially when combined with on-chain transparency and modern data pipelines.

4.3 The regulatory angle: from reporting to 'computable supervision'

A mid-term strategic opportunity is to move from static reporting toward more continuous, data-driven supervision. This is sometimes described as embedded or 'computable' supervision. Quantum computing is not a prerequisite for that evolution, but it could make high-frequency, high-dimensional supervisory analytics more feasible, particularly for complex market infrastructures.

The policy challenge is to ensure that advanced analytics improves accountability rather than obscuring it. Supervisors and regulated firms should therefore co-develop validation standards and transparency expectations early, so that any future quantum-enhanced models remain explainable and auditable.



5. Long-term (5 to 10+ years): new market paradigms under relaxed compute constraints

Longer-term projections are inherently uncertain. The right way to think about the long horizon is not to predict a specific technology milestone, but to ask: if certain classes of optimisation and simulation become cheaper, which market functions change? Three possibilities are worth tracking.

5.1 Financial engineering with richer state spaces

When models are expensive, product design is constrained to what can be priced, hedged, and risk-managed at scale. If compute constraints loosen, institutions may explore more tailored risk-transfer structures, multi-asset contingent claims, or new forms of automated market making that depend on large state spaces. The likely result is not a wave of exotic products; it is a gradual shift toward more granular and dynamically managed instruments.

5.2 Market microstructure and information asymmetry

Computational advantage can translate into market power. If some firms can solve optimisation or prediction problems materially faster, they may obtain a microstructure edge, particularly in liquidity provision and execution. Over time, this could reshape intermediation, reinforce concentration, or create new forms of information asymmetry. This is an area where regulators may need to revisit fairness and resilience expectations, especially in markets where automated strategies dominate.

5.3 Governance frameworks for quantum-enhanced finance

A mature quantum era would demand governance that spans model risk, cyber resilience, third-party concentration, and operational continuity. The governance question is especially relevant for digital organisations such as DAOs and token-issuing entities: how should responsibilities, audit rights, and accountability be defined when key functions are algorithmic and potentially dependent on specialised compute infrastructure?

6. Why ADGM is strategically well placed

ADGM has cultivated a distinctive positioning in digital finance: a pragmatic regulatory approach combined with institution-building that supports new organisational forms. Two elements are particularly relevant for quantum experimentation in finance.

First, a mature virtual-asset regulatory framework. FSRA's virtual-asset regime and its ongoing guidance updates provide clarity for market participants and create a credible environment for responsible innovation.

Second, the DLT Foundations regime as enabling infrastructure. The Registration Authority's DLT Foundations framework has been positioned as a pioneering structure for DLT-native organisations

and token issuance. That institutional infrastructure can be leveraged to convene industry pilots, align governance expectations, and create trusted collaboration vehicles, e.g. sector consortia for shared testbeds, standards, and training.

In practical terms, ADGM can act as a neutral convener across regulators, banks, VASPs, and technology providers. A credible pathway is to pair quantum-security initiatives (post-quantum cryptography transition, QKD demonstrations, key-management modernisation) with a parallel track of business-value pilots (optimisation, simulation, and supervisory analytics). The result is a coherent narrative: security as a foundation, opportunity as the differentiator.

7. Strategic questions for financial institutions

Institutions do not need to bet on a single timeline, but they do need to make choices. The following questions can guide strategy and investment:

1. Where do we face recurring optimisation or simulation bottlenecks that materially affect capital, liquidity, or profitability?
2. What would a 10x faster decision cycle enable in our business model (e.g. intraday risk, collateral optimisation, execution quality)?
3. Which datasets, models, and pipelines must be made reproducible and well-governed before we can credibly trial hybrid quantum methods?
4. How do we avoid vendor lock-in while still learning fast (portability of workloads, open benchmarks, and multi-provider pilots)?
5. What is our quantum security plan (cryptographic inventory, migration roadmap, and third-party readiness), and how does it interact with operational resilience?

8. A practical 90-day agenda (no waiting for fault-tolerant QC)

A short agenda can create momentum without over-committing resources. A pragmatic 90-day programme would:

- Define 3 to 5 use cases and success metrics; include at least one operational optimisation case, not only front-office problems.
- Create a small cross-functional working group (business owner, quant/analytics, IT security, model risk, legal/compliance).
- Build an initial cryptography inventory and identify 'harvest now, decrypt later' exposure for long-lived data.
- Run a benchmark exercise on classical baselines (current solver performance, scenario-generation runtime, calibration cost).
- Engage with the local ecosystem (academia, vendors, and regulators) to align experimentation with governance and learning objectives.



Conclusion

Quantum computing should be treated neither as hype nor as a purely defensive problem. Its strategic significance for finance lies in the possibility that certain optimisation and simulation tasks become cheaper, changing what is feasible in market design and risk management. The early years will be hybrid and experimental, which makes governance, benchmarking, and skills-building the true first-mover advantages. For ADGM, the opportunity is to combine pioneering digital asset regulation and institution-building with carefully governed pilots, turning a quantum-security conversation into a broader market-structure innovation agenda.



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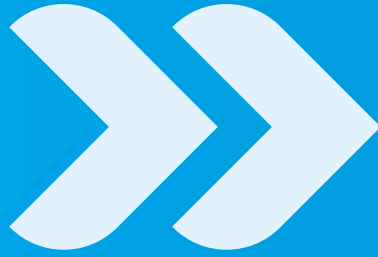
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