

Applications of Quantum Computers in Banking

Q-Con Conference: Quantum, Applied. Value, Delivered

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Q-Con Quantum Conference

- Academic
 - Theoretical physicist and Business Engineer; solved the “fallacy of large numbers” puzzle (Samuelson).
 - Challenged Markowitz’s Mean Variance Theory, developed Maslowian Portfolio Theory.
- Career
 - Fortis/BNP (capital-guaranteed funds, director),
 - KBC (merged companies, CEO, market growth).
 - CIO of KBC Ireland (€32B, 1000 funds).
 - Head of Analytics RBS (financial risk, analytics, data)
 - SVP at HSBC (Model Risk Management CoE).
- Author: “The Big R-Book” and numerous scientific papers.



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Quantum Computing in Banking

Use cases in banking

- **Optimization:**
 1. portfolio optimization
 2. collateral optimization
 3. stress testing
 4. transaction settlement
 5. asset pricing
 6. ATM replenishment
- **Machine Learning**
 1. fraud detection
 2. credit scoring
 3. synthetic data and data augmentation

Use cases in banking

- **Optimization:**

1. portfolio optimization
2. collateral optimization
3. stress testing
4. transaction settlement
5. asset pricing
6. ATM replenishment

- **Machine Learning**

1. fraud detection
2. credit scoring
3. synthetic data and data augmentation

- **Simulations:**

1. random number generator
2. Monte Carlo, PDE simulations, etc.
3. asset valuation
4. ES and VaR calculations

- **Encryption:**

1. quantum key encryption
2. quantum currency
3. quantum blockchain

Resulting Advantages

- quadratic to exponential speedup
- better risk management
- lower costs
- greener computing
- better forecasting
- more suitable investments
- etc.

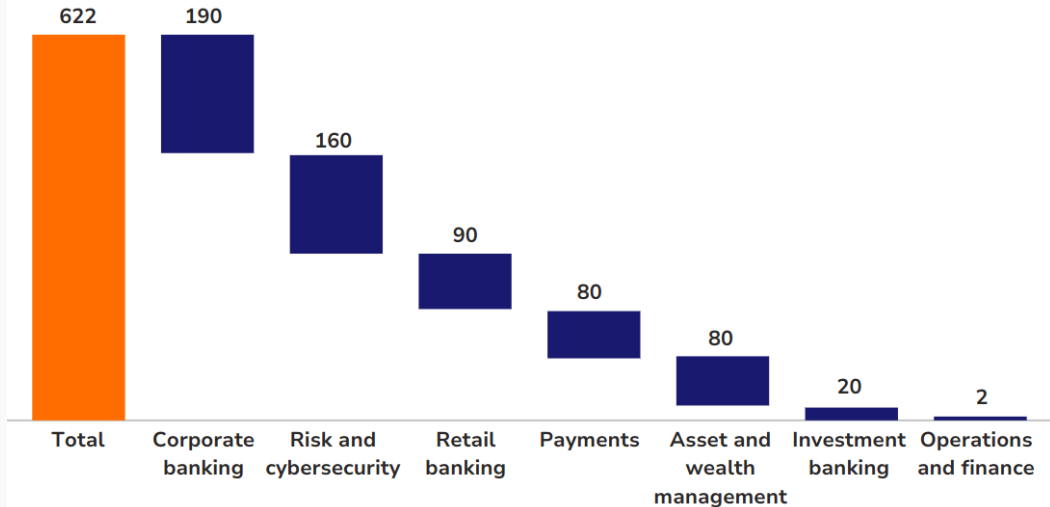
Boston Consulting Group estimates a value of \$42B to \$67B for financial institutions (May 2019). Their 2026 update read: \$450 billion to \$850 billion in total global economic value by 2040.

Overview: Quantum Algorithms for Finance

Approach	Applications	Algorithms	Challenges	Advantages	Timeline		
Stochastic modeling	● Pricing ● Risk modeling ● Credit Risk	Quantum Carlo	Monte Carlo	Data loading into qubits	Quadratic speedup	Long term	
		Quantum solvers	PDE	Input/Output bottlenecks	Unproven speedup	Long term	
Optimization	● Portfolio mgmt ● Financing ● Resource allocation	Convex solvers (SCP)		Hardware limits	precision	Unproven speedup	Long term
		Integer solvers (MIP)		High circuit complexity		Theoretical quadratic speedup	Long term
		Heuristic solvers (QAOA/Annealing)		Noise & tuning	parameter		Early empirical evidence
Machine learning	● Forecasting ● Anomaly detection ● Recommendations	Quantum-enhanced ML		Data loading into qubits		Unproven speedup	Long term
		Quantum-native ML		Training & measurement noise		Unproven speedup	Near term

The Value for Bankers

Value Of Quantum-Computing Use Cases, by Business Unit (US\$ billion)



Note: Assumes that 50% of the full potential in the finance industry will be realised by 2035.

Source: McKinsey & Company, 2023.

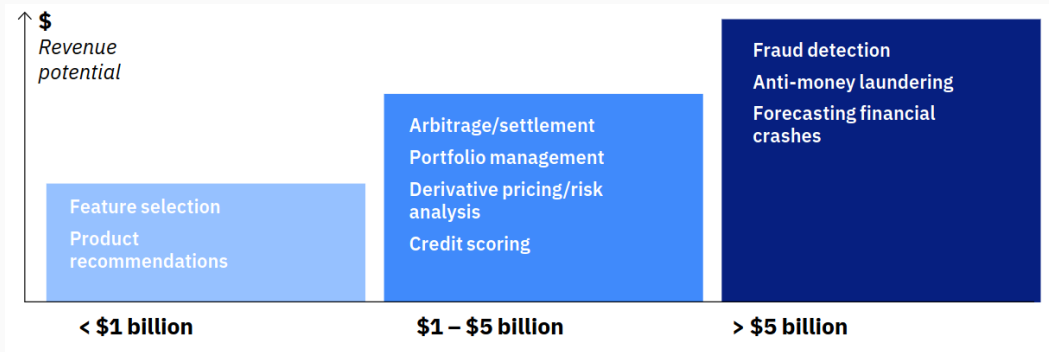


Figure 1: Source: IBM Report: Exploring quantum computing use cases for financial services. These numbers are the average annual savings for the average bank.

Real Examples



Examples of Banks' Efforts



News



Citi joins \$25 million round in quantum pioneer QC Ware

30 September 2021



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JPMorgan Chase, Toshiba and Ciena Build the First Quantum Key Distribution Network Used to Secure Mission-Critical Blockchain Application

NEWS

JPMorgan Chase, Toshiba and Ciena Build the First Quantum Key Distribution Network Used to Secure Mission-Critical Blockchain Application

Proof of Concept Showed Ability to Detect and Defend Against Potential Threats and Eavesdroppers

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Goldman Sachs

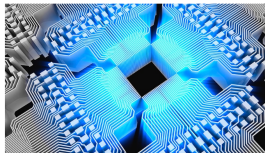


Careers



Possibilities Stories

Investing at Quantum Speed



In a giant leap forward for the world of finance, Goldman Sachs announced we can introduce quantum algorithms to price financial instruments in as soon as five years.

We're on the verge of using quantum algorithms to do complex financial calculations with blazing speed. Finance was one of the first domains to embrace Big Data, and the drive to innovate continues. Much of the science behind the pricing of financial assets involves combinatorics calculations, the forte of quantum computing.



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11 Global Banks Probing The Wonderful World of Quantum Technologies



By James Dargan June 23, 2021

IBM

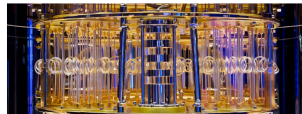


HSBC Working with IBM to Accelerate Quantum Computing Readiness

Bank envisions application of quantum capabilities for priorities such as pricing and portfolio optimisation, sustainability, risk and fraud

Expands internal talent with quantum specialists

Mar 29, 2022



IBM Research Blog

Topics

Labs

News Flash

IBM and Wells Fargo Collaborate to Accelerate Innovation

November 15, 2019 | Written by: IBM Research Editorial Staff

HSBC & BT: Quantum Key Distribution for FX Trading (2023)

Application Domain: Post-Quantum Financial Infrastructure Security
Securing live Foreign Exchange (FX) trading transactions with QKD.



- **Mechanism:** Connected HSBC's global HQ in Canary Wharf to a primary data center in Slough via BT and Toshiba's commercial **Quantum Key Distribution (QKD)** network over standard fiber optics.
- **Operational Scope:** Integrated QKD directly into live FX trading systems processing over \$2.5T in daily transaction flows.
- **Key Breakthrough:** First commercial bank to deploy QKD on live financial trading infrastructure, neutralizing "harvest now, decrypt later" cyber attacks.

Reference

HSBC & BT Media Release, *"HSBC becomes first bank to join BT and Toshiba's commercial quantum-secured network"* (July 2023).

HSBC & IBM: Algorithmic Trading Execution (2025)

Application Domain: Corporate Bond Market Liquidity

Predicting trade fill probabilities for corporate bond orders on live market infrastructure.



- **Mechanism:** Utilized IBM System 2 with **Heron processors** running Variational Quantum Eigensolver (VQE) and Quantum Support Vector Machine (QSVM) algorithms.
- **Data Scale:** Benchmarked against over 1,073,926 Request-for-Quotes (RFQs) in the European corporate bond market.
- **Empirical Outcome:** Achieved an empirical **34% relative improvement** in out-of-sample order-fill prediction accuracy over classical baselines.

Reference

HSBC Media Release & IBM Quantum Research, *"HSBC demonstrates world's first-known quantum-enabled algorithmic trading"* (September 2025).

Mastercard & OQC: Real-Time Fraud Detection (2026)

Application Domain: Payment Network Anomaly Filtering

Minimizing false-positive declines without violating strict sub-millisecond payment settlement SLA constraints.



- **Mechanism:** Implemented a **Hybrid Ensemble Routing Architecture**. Standard low-risk transactions are handled classically, while ultra-high-dimensional feature vectors are dynamically routed to Oxford Quantum Circuits' superconducting processors.
- **Key Breakthrough:** Maintained sub-millisecond network latency while boosting classification precision for edge-case payment fraud.

Academic & Industry Reference

Mastercard & Oxford Quantum Circuits Joint Case Study, *"OQC and Mastercard Demonstrate Quantum-Enhanced Fraud Detection"* (June 2026).

JPMorgan Chase & Quantinuum: Certified Randomness (2025)

Application Domain: Post-Quantum Security & Monte Carlo Entropy

Generating hardware-verifiable non-deterministic entropy for encryption key generation and financial simulation.



- **Mechanism:** Executed phase estimation on a 56-qubit trapped-ion processor (*H-series*), validating entropy output through supercomputing clusters at U.S. National Laboratories.
- **Empirical Outcome:** Proven mathematical non-determinism, replacing classical Pseudo-Random Number Generators (PRNGs) vulnerable to quantum side-channel decryption.

Academic & Industry Reference

JPMorgan Chase, Quantinuum, et al., "*Quantum-verified random numbers*", published in **Nature** (March 2025).

Application Domain: Multi-Asset Exotic Option Valuations

Pricing complex derivatives with non-linear payoff structures using Quantum Amplitude Estimation (QAE).



- **Mathematical Speedup Proof:** Classical Monte Carlo algorithms require $\mathcal{O}(1/\epsilon^2)$ iterations to reach precision ϵ , whereas Quantum Amplitude Estimation achieves:

$$\mathcal{O}\left(\frac{1}{\epsilon}\right) \quad \text{vs. Classical} \quad \mathcal{O}\left(\frac{1}{\epsilon^2}\right)$$

- **Impact:** Enables real-time risk sensitivity calculation (Greeks) for large multi-asset derivatives portfolios during volatile trading sessions.

Academic & Industry Reference

Goldman Sachs & QC Ware, "Option Pricing using Quantum Computers", arXiv:1905.02666 / Journal of Quantum Computing.

Crédit Agricole CIB & Pasqal Counterparty Credit Risk (CCR)

- **Tech:** Neutral-atom quantum processors.
- **Goal:** Calculation of Value-at-Risk (VaR) and Risk-Weighted Assets (RWA).
- **Outcome:** Faster evaluation of default probability under systemic market stress.

Ref: Crédit Agricole CIB / Pasqal Press Release (2026).

BBVA & Multiverse Computing Dynamic Portfolio Rebalancing

- **Tech:** D-Wave Quantum Annealers & Variational Circuits.
- **Dataset:** 8 years of historical price data with real transaction fees and liquidity limits.
- **Outcome:** Reduced runtime from 2 days to seconds with superior Sharpe ratios.

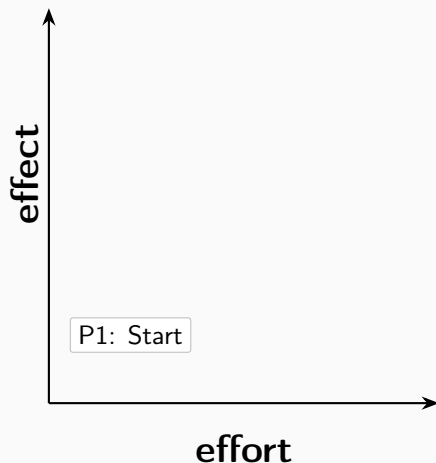
Ref: BBVA Research, arXiv:2007.00017.

Summary: Proven Institutional Case Studies

Institution	Domain	Hardware Partner	Key Benchmark / Outcome
HSBC	Bond Trading	IBM Heron	34% relative gain in fill accuracy
Mastercard	Fraud Detection	OQC Superconducting	Sub-ms hybrid network routing
JPMorgan Chase	Cryptography Entropy	Quantinuum Trapped-Ion	Verifiable hardware random keys
Goldman Sachs	Option Pricing	QC Ware NISQ	Quadratic speedup $\mathcal{O}(1/\epsilon)$
BBVA	Portfolio Optimization	D-Wave Annealer	Runtime reduced from 2 days to secs

The Route to Quantum for the Banker

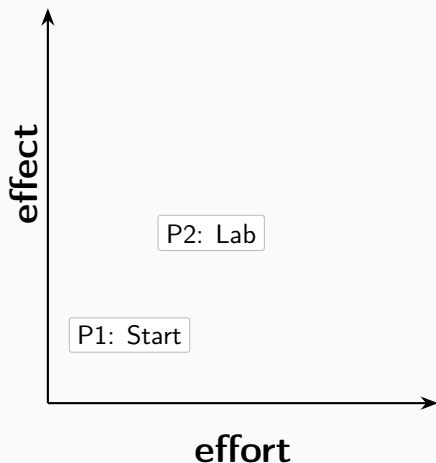
Solutions: Constructing the Bank's Roadmap



Strategic Phases:

- **Phase 1 (Start):** Internal Capability Building & Use-Case Identification

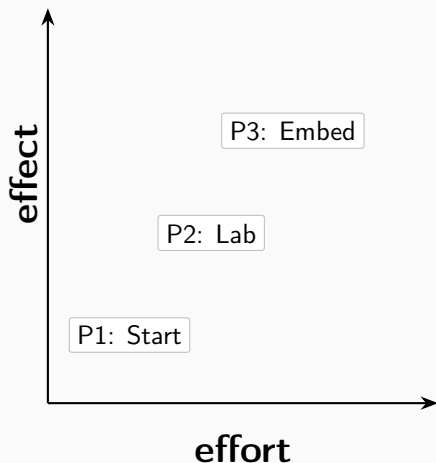
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Strategic Phases:

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- **Phase 2 (Lab):** Cloud-based PoC Development (QCaaS)

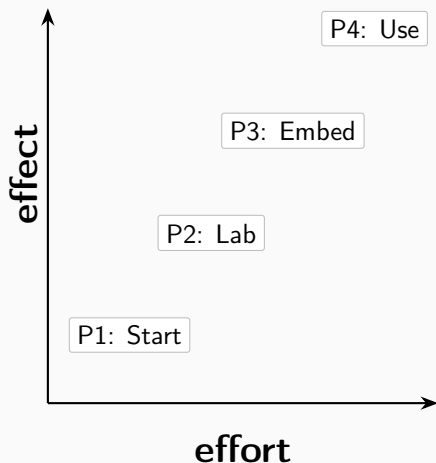
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Solutions: Constructing the Bank's Roadmap



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- **Phase 4 (Use):** Hybrid Classical-Quantum Production Systems

Conclusion

1. **Post-Quantum Preparedness:** Migration to Quantum Key Distribution (QKD) and post-quantum encryption.

Strategic Takeaways for Financial Institutions

1. **Post-Quantum Preparedness:** Migration to Quantum Key Distribution (QKD) and post-quantum encryption.
2. **Go Hybrid:** Both hybrid classical-quantum and ensemble approaches.

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3. **Quadratic & Exponential Vectors:** Watch high-dimensional feature selection and Monte Carlo simulation.

Strategic Takeaways for Financial Institutions

1. **Post-Quantum Preparedness:** Migration to Quantum Key Distribution (QKD) and post-quantum encryption.
2. **Go Hybrid:** Both hybrid classical-quantum and ensemble approaches.
3. **Quadratic & Exponential Vectors:** Watch high-dimensional feature selection and Monte Carlo simulation.
4. **Develop a Strategy:** Build quantum capabilities ecosystem, forge relations, adopt early.

Case Studies & Papers Cited in Presentation

- G. Palmer et al. (2021), "Financial Portfolio Optimization with Quantum Annealers" – arXiv:2106.06735
- IBM Institute for Business Value (2020), "Exploring quantum computing use cases for financial services" – IBM Report
- HSBC & IBM (2025), "HSBC demonstrates world's first-known quantum-enabled algorithmic trading" – Media Release
- Mastercard & Oxford Quantum Circuits (2026), "OQC and Mastercard Demonstrate Quantum-Enhanced Fraud Detection" – Joint Case Study

References & Further Reading ii

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- Goldman Sachs & QC Ware (2019), "Option Pricing using Quantum Computers" – arXiv:1905.02666
- Crédit Agricole CIB & Pasqal (2026), "Counterparty Credit Risk (CCR) Evaluation via Neutral-Atom Quantum Processors"
- BBVA Research (2020), "Dynamic Portfolio Optimization with Quantum Annealers" – arXiv:2007.00017

Industry Reports & Strategic Reading

- McKinsey & Company (2020), "How quantum computing could change financial services" – McKinsey Insights
- IBM Institute for Business Value (2021), "The Quantum Decade" – IBM IBV

Foundational & Academic Textbooks

- E. Rieffel and W. Polak (2011), "Quantum Computing: A Gentle Introduction", MIT Press – MIT Press
- C. Hughes et al. (2021), "Quantum Computing for the Quantum Curious", Springer – PDF Download (Open Access)

Thank you for your attention!



handouts



Philippe's business card