

Research Statement — Faisal Shah Khan

My research is guided by a fundamental question: How does the structure of quantum information reshape the way multi-agent systems make decisions, interact, and create value?

Quantum Information and Strategic Systems

I explore this question at the intersection of quantum information theory, game theory, and financial systems, focusing on how quantum features — such as entanglement and discord — alter the logic of strategic behavior. Working with collaborators, I have developed trading models in which correlations sourced from quantum entanglement reshape the strategy space in noncooperative games and enable access to equilibria beyond the classical setup. This project is ongoing and will see development and implementation through a collaboration with the National Quantum Laboratory at University of Maryland in coming months and possibly longer.

In another line of research, I have analyzed how quantum discord can serve as a substitute for memory in sequential games, enabling agents to recover performance lost to imperfect recall. This line of inquiry — a quantum analogue of Kuhn's Theorem — demonstrates how informational structure itself can compensate for limitations in memory and signaling, redefining how agents reason within distributed systems.

This theoretical program has evolved into what I describe as quantum data science — a field concerned with modeling, interpreting, and acting on signals produced by quantum systems. Such signals carry the imprint of entanglement or discord yet appear classical to the observer. They offer a bridge between the underlying quantum structure and the patterns expressed in classical data. My work develops methods to extract and apply these signals for predictive, analytical, and design purposes, transforming abstract quantum features into operational decision tools which will be indispensable in the near future where quantum information will be present in networked environment.

From Theory to Application

At DP World, a global logistics company operating ports and supply chains worldwide, I applied quantum annealing techniques to quadratic optimization problems in container logistics. These models demonstrated how quantum hardware can improve routing and scheduling efficiency in large-scale industrial systems. At Khalifa University, a leading research institution in the United Arab Emirates, I directed projects on quantum-safe communication and quantum random number generation, building secure, hardware-based randomness sources for use by the university's research community using off-the-

shelf commercial equipment. These experiences grounded my theoretical interests in real-world implementation, illustrating how quantum technologies can create tangible operational and informational value.

Future Directions

Looking ahead, my research advances along three interconnected lines:

Quantum Market Design — modeling systems where quantum informational structure defines value and incentive.

Quantum Signal and Data Analysis — interpreting and applying data generated by entangled or discordant systems.

Quantum Memory and Strategy — developing game-theoretic tools to reason under distributed, imperfect-recall conditions.

My aim is to continue advancing these lines of inquiry while building a research environment where students engage directly with foundational and emerging questions in quantum information. I see the opportunity to involve undergraduates in every stage of this work — from theoretical modeling to experimental design — in a setting that encourages both precision and breadth. Quantum information challenges us to rethink concepts as basic as memory, value, and choice. They demand new tools, but also new ways of asking questions, a challenge I welcome, and one I believe students can meaningfully take up.