Philadelphia Fed

Perspective

Spooky Science: Quantum Computing, the Fed, and the Future

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Another great technological leap is on the horizon as quantum computing presents a way to turbocharge our computing power. As the nation's central Bank, we’re at the forefront of exploring how this innovation, with its benefits and risks, can strengthen our nation's financial infrastructure.

Ever since I was a little boy taking apart transistor radios to see the magic inside, I’ve been fascinated with the way things work. Or as my family and friends have sometimes more bluntly put it, I’ve always been a tech geek. Now, as president of a Reserve Bank and chair of a Federal Reserve committee focused on technology, I put my interest in the subject to work each day.

Luckily for me and my fellow techies, ours is an age of remarkable innovation. From the development of personal computers, smartphones, and the Internet to the rise of gene therapies, stem cell treatments, and carbon-zero electricity, technological development has a played a part in making the world more healthy, green, convenient, and — as we all know — at times distracting.

We now stand at the precipice of another great technological leap: the development and deployment of quantum computing, a potentially revolutionary technology. This is an exciting time, full of opportunity but also fraught with no small amount of risk. The Federal Reserve, as the nation’s central bank and a regulator, has a strong interest in fostering an environment that is conducive to innovation and that safeguards our country’s financial infrastructure.

So, what is quantum computing? To begin to answer that question, it helps to think a little bit about quantum mechanics.

Quantum mechanics is a branch of theoretical physics that is, fundamentally, the study of very, very small things — specifically, the behavior of matter and light at subatomic scales. These tiniest discrete units are called *quantum particles*.

Once you get to such a tiny scale, things behave strangely. They don’t act at all like the objects we see in our day-to-day lives.

Quantum particles can, for instance, be in a state of *superposition*, which is not easy to get your head around. During superposition, quantum particles are simultaneously in a combination of all of their possible states. Imagine a quarter that shows both heads, tails, and every state in between, at the same time, which would definitely complicate an NFL coin toss.

And then, there's *quantum entanglement*. What is it? I like this description from Cal Tech: "When two particles, such as a pair of photons or electrons, become entangled, they remain connected even when separated by vast distances. In the same way that a ballet or tango emerges from individual dancers, entanglement arises from the connection between particles."

No wonder Albert Einstein once described quantum entanglement as "spooky action at a distance." Or, if you prefer a more scientific term than "spooky," you could also say "weird."

What's so exciting is that quantum computing is making what was formerly theoretical, real.

Here's how: Quantum computing builds on the insights found in quantum mechanics to vastly expand computing power. Instead of just zeros and ones, quantum computers employ quantum principles like superposition and entanglement. Instead of "bits" — zeros and ones — quantum computers use what are called *qubits*. That is, they compute using zeros, ones, and everything in between — simultaneously. This makes them extraordinarily powerful when it comes to performing tasks like machine learning, search, and cryptography. These are the true supercomputers of a rapidly approaching future.

Here, I think, the opportunities and risks for governments, businesses, institutions, and even individuals are clear. Whether you call it spooky, weird, or just plain exciting, there can be no doubt that quantum computing has the potential to revolutionize our world.

Imagine, for instance, quantum computers simulating the structure, properties, and behavior of molecular structures, the building blocks of pharmaceuticals. The benefits for drug development could be profound.

Or imagine financial institutions using quantum computing to more accurately calculate risk, allowing them to promote inclusion while simultaneously strengthening their balance sheets and reducing threats to the financial system.

Closer to home, deploying quantum technologies to run economic models could greatly strengthen our understanding of the economy and the way it reacts to shifts in the Fed's monetary policy.

All in all, it's little wonder that some of the biggest names in technology, banking, and pharmaceuticals are making heavy investments in quantum technology.

A cause for more worry is the prospect of quantum technologies falling into the wrong hands. One thing is for certain: Current methods of encryption will not stand up to quantum cryptography. Governments, corporations, and institutions are already working hard to develop quantum-safe encryption and that's a good thing. The cyber environment is already rife with threats from malevolent state actors to online bandits, and quantum technologies will only intensify them. For our part, making sure the financial system and the Federal Reserve are secure is at the top of our priority list.

You can learn more about quantum computing in this video and take a deeper look at some of the challenges posed by quantum computing in this paper from the Global Risk Institute.