

## Interview – David Orrell

Written by E-International Relations

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David Orrell is an applied mathematician and writer. He studied at the University of Alberta and obtained his D.Phil. in mathematics from Oxford University. He has worked in diverse areas from systems biology to quantum economics. His books on science and economics have been published in twenty countries. Orrell's work points out to the limits of mathematical models, particularly economic ones, as argued in *Apollo's Arrow: The Science of Prediction and the Future of Everything* and *Economyths: Ten Ways Economics Gets It Wrong*. As a leading proponent of quantum finance and quantum economics and co-author of *The Evolution of Money*, Orrell proposes a quantum theory of money and value, which states that money has dualistic properties because it combines the properties of an owned and valued thing, with those of abstract number. As of today, he is a founding editor of the new journal Quantum Economics and Finance. He lives in Toronto.

### Where do you see the most exciting research/debates happening in your field?

In economics, the most exciting project in my view involves building an alternative to mainstream theory that is based on quantum rather than classical thinking. The field of economics has been in a rut for many years. Core ideas like the law of supply and demand date back to the Victorian era, and the failure of models during the financial crisis led to little real change. Newer approaches such as behavioural economics or systems dynamics are certainly useful but have had limited impact, in part because they don't go far enough. For example, behavioural economics adjusts classical theory without really challenging the central idea of rational utility optimisation.

Quantum economics is a completely new approach because it is based on a different kind of logic. In the classical picture, rational and independent investors drive prices to a stable equilibrium which reflects intrinsic value. In the quantum picture, prices are inherently uncertain, investors are influenced by subjective factors, people are financially and socially entangled, and as a result markets are unstable – and a lot more interesting.

The field is in an exciting stage because quantum models are promising to offer new answers to key problems in economics and finance. For example, one of the oldest such problems is the pricing of options (those financial instruments which give the holder the right to buy or sell an asset at a future date for a set price). The classical theory of option pricing, which is based on the Black-Scholes model from 1973, has been described as the most accurate theory in economics, but the quantum model shows that for commonly-traded options and standard parameters it can be out by 40 percent. The fact that it still serves as the benchmark model is like a magic trick (see also here), where people don't focus on the obvious flaws because they are distracted by the elegant and persuasive theory.

Advances in the field are also being driven by the development of quantum computing. Mainstream economics was shaped by the development of computers in the post-war era, and quantum computers are changing the way we think about the economy. For example, you can model the financial entanglement between a debtor and creditor as a quantum circuit, and similar circuits are used in quantum cognition to model how we make decisions, or in quantum computers to run artificial intelligence algorithms. Today a high school student can run quantum circuits to model the prisoner's dilemma game which is new.

### How has the way you understand the world changed over time, and what (or who) prompted the most significant shifts in your thinking?

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There have been many changes and influences along the way, but to focus on one, my experience doing my D.Phil. on model error in weather forecasting changed the way that I thought about science and made me much more skeptical about things like incentives and the role of mathematical models. At the time there was a belief that weather models could be treated as essentially perfect so all error came from the inputs to the model – i.e. measurement of the current weather – amplified by chaos (the butterfly effect). This meant that forecasters just needed to run many forecasts from perturbed initial conditions, which of course required more computers and bigger budgets. Having worked already on some engineering projects, my view – and that of my supervisor Lenny Smith – was that the main problem wasn't chaos or the butterfly effect, it was just that models were wrong, because you can't build a perfect model of the weather. (It's amusing how people are skeptical about things like quantum approaches, but unskeptical about models once they become established.)

Economics is an example of a field where the dominant ideas only make sense when you think of the incentives involved. During the Cold War, the promotion of results such as the Arrow-Debreu model of competitive equilibrium, which purported to prove the optimality of free markets, was as much about propaganda as science. The efficient market hypothesis – which states that prices adjust to new information immediately – is the economics equivalent of the perfect model hypothesis in weather forecasting because it assumes the equilibrium model is perfect. And mainstream economics, with its emphasis on efficiency, rationality, stability, and optimality, often sounds like the PR wing of the financial sector.

As with many other people (including a significant number of economics students), the 2007/8 crisis, when markets seemed less than stable or efficient, certainly changed the way I thought about economics. The Occupy Wall Street movement in 2011 was kicked off by Adbusters magazine, whose issue at the time featured an extract from my book *Economyths*, giving a call for economics students to overturn neoclassical orthodoxy and “do something new”. For me, that turned out to be quantum economics.

**In recent years, James Der Derian initiated Project Q, Alexander Wendt published *Quantum Mind and Social Science*, and you are co-editor-in-chief of the new journal *Quantum Economics and Finance*. Is it fair to say that academia is starting to investigate the implications of quantum discoveries for the social sciences more seriously?**

I had the pleasure of meeting Der Derian and Wendt at a quantum conference Wendt organised at Ohio State University in 2018. I really enjoyed the conference because everything seemed so wide open. It's true that some in academia are starting to take quantum ideas a little more seriously but an interesting question is why it took so long (over a century!), and I would argue there has been a taboo on quantum which is only now being relaxed.

Part of this has to do with some physicists protecting what they see as their turf, but there seems to be a psychological or sociological component as well. One (not universally accepted) theory I put forward in a piece called “A softer economics” is that it relates to the role of gender.

The traditional, billiard-ball view of classical mechanics encodes stereotypically male values like solidity and certainty while quantum, which is based on wave functions and features uncertainty and entanglement, is more yin than yang. Some people get annoyed by the triteness of this idea but for me it seems reasonable, especially given the level of gender bias in both physics and economics. I suspect that if quantum had been discovered by women, instead of a group of young men, we would be calling it the most feminist theory ever. What happened though was that quantum was branded as quantum mechanics, and was considered okay for things like nuclear weapons, but if anyone tried to apply the ideas to human behaviour they were quickly slapped down.

In any case the fact that there has long been a taboo on the use of quantum outside physics, which has only recently been relaxed, is actually a real advantage for a new researcher because when such attitudes change, they tend to change quickly. Certainly, in economics, the number of people involved feels like it is in its exponential growth stage, which is why we decided to start a new journal.

**Your new journal *Quantum Economics and Finance* sheds light on the use of quantum probability as a**

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### **tool with which to illuminate our understanding of economics and finance. How is this achieved?**

To give some background, related fields such as quantum cognition, quantum game theory, and quantum finance have been around for some decades, but there were no specialised journals, so people would end up publishing usually in physics journals where the topic was viewed as a sideshow. I saw the need to start a new journal while researching my book *Quantum Economics*, and teamed up with Emmanuel Haven who co-authored the book *Quantum Social Science* and set up the Centre for Quantum Social and Cognitive Science (CQSCS) at Memorial University.. Thanks to the team at Sage Publications we finally managed to get the QEF journal set up earlier this year (2023), with Ray Hawkins joining as managing editor soon after. Emmanuel started his academic career in finance and then went quantum, while Ray trained in quantum physics and then worked in finance, so we have all followed different paths. The editorial board has backgrounds encompassing economics, quantitative finance, mathematics, physics, quantum computing, complexity theory, game theory, psychology, and so on.

Quantum is from the Latin for “how much” and the idea of the journal is that quantum methods apply very well to the economy, where transactions are a way of answering the question “how much?”. The fuzzy notion of value is modelled as a wave function which when measured through transactions collapses down to a number, namely the price. This approach allows us to integrate the dynamical and probabilistic nature of decisions and transactions in a very natural way. In individual decisions, the wave function captures things like subjective factors which don’t appear in the classical analysis. In a model of the stock market, rotations of a quantum wave function represent the level of activity. (As a mental image, think of a skipping rope frozen in the shape of a bell curve. That’s classical probability, of the sort used in traditional theories like Black-Scholes. Now think of the same rope spinning around and distorting with speed, as if someone is actually skipping. That’s the quantum model.)

A basic question of course is whether the quantum approach is justified in an area like economics. The test of this is not whether we think it is permissible to adapt quantum ideas from physics, but a much harder one: it is whether, if the ideas had not existed, economists would have wanted to invent them. So, the aim is to produce models which meet that test, by making useful and accurate predictions.

Of course, what counts in economics is not just the mathematical models, but more broadly the underlying mental model of how things work, and here the quantum framework gives us a richer way of thinking about the economy as being made up of living, uncertain, entangled beings, rather than the classical picture of utility-optimizing “rational economic man”. And the area is very multidisciplinary. It’s interesting to see scientists from quantum computing firms teaming up with psychologists to model cognition, or a sociologist writing about the role of quantum social entanglement in the response to the climate crisis, or a physicist modelling retirement income.

### **Your proposed quantum approach offers a new insight outside the canon of International Relations to a neglected yet critical topic: the value of money. In what ways has money been overlooked in the study of international affairs?**

As I argued in a paper for Security Dialogue, a main insight of the quantum approach is that money has an intrinsically dualistic nature, because it is a way to assign number to value, and these have incompatible properties (for example you can give someone a valuable object, but you can’t give them a number). As with quantum, there is unease around discussing money, and perhaps surprisingly this extends even, or especially, to the field of economics, where money is rarely discussed except as an inert metric, and topics like money creation were long treated as no-go areas, as researchers such as Richard Werner have pointed out.

When I submitted that paper an early reviewer seemed a little befuddled by what they described as a “detour” into the subject of money – even though money is obviously core to how countries interact (US power is related to the US dollar; and if you live in a country with an unstable currency, a dollar or a Euro is not an “inert metric” when you have to pay a debt in it). One thing is that academics working in the social sciences (with exceptions such as the late Susan Strange) may be uninterested in the topic of money, but also have a kind of grudging respect for economists so want to keep off their turf. But most economists have no clue about it either because it doesn’t fit into their classical worldview. In quantum economics, the complex, dualistic nature of money is taken as the starting point.

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### **Could it be argued that information is analogous to money in the global system with the understanding that information is the fabric of the collective consciousness and international entanglement?**

Yes, the emphasis on information is important, and it is what makes quantum an appropriate framework for the social sciences. As the quantum computer scientist Scott Aaronson (who is not involved in quantum economics) wrote, quantum probability is “about information and probabilities and observables, and how they relate to each other.” In physics, concepts such as superposition, interference and entanglement are applied to subatomic particles; in the social sciences, they are applied to ideas and information. For example, we can hold two ideas in our head at the same time, and they may interfere, or be entangled with other peoples’ ideas. Money is a particular form of information, which is used to collapse the fuzzy idea of value down to a hard number. There have been many theories of money, but most of these neglect its most basic property, which is its relationship to number.

### **Are there limitations of applying quantum ontology and methodology to the study of economics, finance, and IR?**

Yes, our fascination with ontology is a problem! The interpretation of quantum physics is a topic of endless (if rather specialised) debate in physics. Quantum researchers in social science tend to follow one of two strands, which respond to this debate in different ways.

The first strand is to say that, according to some theories, the brain is based on quantum processes; so if that can be shown to be true, then it will follow that we are quantum and the social sciences need to be quantum too. However, while neurons may indeed turn out to exploit quantum effects, I find this argument to be rather reductionist, and don’t see what difference it would really make to a field such as economics: just because water is quantum doesn’t mean we expect plumbers to retrain in quantum mechanics, because what counts is the emergent properties. Or viewed the other way, the fact that a quantum model works well for something like the stock market doesn’t mean stocks are somehow ontologically at one with electrons.

The second strand, popular in quantum cognition, is the “quantum-like” approach which says we can borrow these models from physics because we are “like” a quantum system. This makes sense if you are trying to explain cognition using physical analogies, or drawing on advanced physics, but if you view quantum as a form of mathematics it doesn’t really work – we don’t say a systems dynamics model is planet-like just because calculus was first applied to planetary motion. And while a mathematical model is related to metaphor, it is different in that for example it can make specific predictions.

Either of these framings lead to confusion about what is “real”. For example, a typical comment (and a reasonable one from a physics perspective) is that a model isn’t “really” quantum because it does not describe “real quantum phenomena.” Yet for someone on a pay-day loan, the entanglement encoded by the information in the debt contract – which again can be written as a quantum circuit – seems pretty real. In general – and this probably comes more naturally to someone trained in the social rather than the physical sciences – information is real, even if it comes from a lawyer rather than the laws of the universe.

While quantum economics does draw on these and other interpretations, it therefore sees quantum probability primarily as a mathematical tool. To quote Aaronson again: “Quantum mechanics is what you would inevitably come up with if you started from probability theory, and then said, let’s try to generalize it so that the numbers we used to call ‘probabilities’ can be negative numbers. As such, the theory could have been invented by mathematicians in the 19th century without any input from experiment. It wasn’t, but it could have been.” It is interesting to think how things would have played out if quantum ideas had been adopted to study human behaviour before they were applied to physics – perhaps physicists would be worrying over whether it was intellectually defensible to model electrons as being like little people.

Again, the test of the quantum approach isn’t whether we have somehow inherited quantum properties such as superposition and entanglement from subatomic particles. Instead, the idea is more in the spirit of the first quantum pioneers, which is to take quantum social properties at face value, and use mathematics in a creative way to model

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observed phenomena. Viewed this way, attempts to relate everything to physics or create a unified ontology are something of a distraction. And we certainly have urgent problems where a quantum perspective would be useful. An example is the climate crisis, which could be viewed as the logical consequence of classical economics, the end result of individual utility-maximizing behaviour. One focus of the QEF journal is to investigate how quantum ideas can help loosen our doomed obsession with a particular type of economic growth.

**In *Economyths: 10 ways economics gets it wrong*, you highlight the intellectual poverty of neo-classical economics. What are the ways in which economics gets it wrong?**

The ten chapters in the original 2010 book were about ideas such as rationality, stability, individuality, and so on which characterise the classical picture of the economy (as opposed to the actual economy). The inspiration for this traditional view is often considered to be Newtonian science, but the ideas actually go back a lot further – in fact the chapter topics were based on a list of ten opposites from the Pythagoreans in ancient Greece. In a revised edition from 2017 I added an extra topic which combined aspects of the others, namely the (again, counterintuitive) fact that economics ignores or downplays the topic of money. This has left economists singularly unequipped to understand how much of the economy actually works. In Canada, for example, the economy is dominated by a housing bubble which economists try to analyse based on the mechanics of supply and demand, but is better understood from a quantum perspective as a money creation scheme – the financial version of a nuclear device – where the banks and some property owners are enriched, but the society as a whole is destabilised.

As Wendt noted in 2005 the same classical ideas have permeated the social sciences, and are backed up in part because of the (now somewhat tarnished) prestige of economics, which is associated with “hard” mathematics. So a first step for quantum economics is to build empirically-grounded alternatives to things like the “law of supply and demand”, the pricing of risk, and so on which out-perform the classical approach. Of course, not all models need to be quantum (and there is no such thing as a perfect model!), but together with other heterodox approaches like systems dynamics, complexity, ecological economics and so on the quantum approach can help reinvent economics. You don’t need to be a quantum expert to get involved.

**How do you find inspiration to think innovatively and come up with unorthodox ideas, at the intersection of different academic disciplines?**

One thing is that I trained in mathematics which allowed me to work across disciplines, including engineering, forecasting, systems biology, and economics (it probably helped that my jobs kept ending; for example, I returned to university after a particle accelerator project I was working on, the Superconducting Super Collider, was cancelled). However, another thing is the combination of science with writing for a general audience, which has been a great way to see topics from different angles. I credit this interest in part to familial influence – my father was an English professor – and also to my undergraduate university (Alberta) where mathematics could be taken as an arts subject, so I got to combine it with things like philosophy, art history, Shakespeare, film studies, and so on (even quantum physics). I also draw inspiration from my wife who as an architect works at the interface of art and engineering.

**What would you say is the most important advice for a young scholar in IR?**

I don’t really feel qualified to answer this one, but (since I’m here) I think the most important advice would be to NOT go into quantum. Sure, the methods can work. Yes, there are low-hanging fruit for early adopters. Okay, it is new and fun. And it is certainly true that the classical approach has failed, or at least run out of tarmac. But any rational person knows that it would be much better to keep in a safe, respected area rather than go down some weird and risky quantum path where the end point, if there is one, is highly uncertain. Of course, a few people will ignore this sensible advice, and we look forward to hearing about their work and maybe receiving their submissions at the journal.