Research Statement

I am a quantitative risk specialist at ABN AMRO Private Banking in the Netherlands, interested in the recognition of complex patterns and hidden structure in dynamical systems: the "red thread" connecting each of the fields in which I've worked.

My current focus is modeling clients' investment risk, which is both a regulated duty for us, and the mission of our team. This motivates taking my research towards a network-aware analysis of investment risk. I believe we need predictive models which go beyond statistical approaches based only on historical data, to capturing the interconnected nature of the companies and economy behind the portfolio.

Current Work

During my PhD I had some fun and eye-opening chats about the financial crash with a good friend, who introduced me to the complexity arising from structured financial products in markets which have rules and intelligent agents. This drew me to quantitative risk management in the post-financial-crisis era. My current work in this field is twofold:

1. On risk modeling, monitoring, and visualization: my team provides both custom analysis to clients, and the risk input for the Global Investment Committee of the bank. I emphasize visualization, which stands out as the key to making complexity intelligible.
2. On smaller research projects, typically clarifying some knowledge we urgently need. Two fairly unique projects have stood out recently, which characterize my interests:
   - I've worked on the design of an approach to risk monitoring through risk bandwidths, which float with market indexes' risk. In effect this gives meaning to the phrase "excessive risk." Such bandwidths are adaptive, and provide a more dynamic picture of where any particular client's portfolio stands with respect to history, and to the current market regime [1].
   - I've also developed the modeling, and major parts of a full transaction-processing, analytics and reporting stack, for an "Investment Game" our team organized for charity. I mapped the 2014 World Cup to a complete investable market, from team stocks through indexes and derivatives [2]. Beyond mathematical curiosity it served an educational purpose for participants, who held diversified portfolios of teams and players, and received both historical and predictive measures of performance and risk (live during the World Cup).

Future Directions

I believe that investment-risk best practices can be improved through research on reconstructed network topologies and dynamical systems. While the community looking at systemic risk in the banking network has already begun to use such techniques, these need to be brought to asset management as well. Three avenues provide inspiration, at different scales:

1. Inferred structure at the trade level, as studied in [3] on market structure, which I recently used in a technical report [4] outlining a framework for integrating the "usual suspects" of market and credit risk with liquidity risk driven by trading dynamics (e.g. in a crisis situation, when panicked selling begins), for the Asian regulatory regime.
2. Inferred structure at the market level, such as the behavior-inspired "herding model" of Sornette *et al.* [5, 6], which can be used as an overlay over risk-bandwidth approaches. These would effect a penalty for risk precisely in an *overheated* bull market (high performance tied to high risk of ruin), via a "bubble indicator" such as the log-periodic oscillations proposed by Sornette.
3. Inference Ising models for network reconstruction inspired by applying techniques from statistical mechanics to *e.g.* finance and neuroscience [7, 8]. These can provide a networked view of the actors in the market, enabling us to take a step beyond naive measures of concentration-risk and counterparty-exposure.

Previous Academic Work

My previous work reflects this ongoing cross-disciplinary interest. In my thesis work in aerospace engineering and math, I formulated a novel approach to determining low-energy transfer orbits for spacecraft. I combined a dynamical-systems approach to astrodynamics with numerical solutions incorporating the dynamical structure of 3-body problems into the solver to increase accuracy. That quantitative modeling exercise became a bridge towards doctoral research at the Kavli Institute of Nanoscience in Delft. I had worked in the van der Zant lab on molecular nanostructures as an undergrad, and then took an opportunity to join the theoretical side of the same research program.

My focus was on efficiently simulating transport in realistic nanostructures, towards developing structures with novel functionality for future electronics. The approach was to write our own DFT+NEGF code[9]. We used density functional theory (DFT) for a quantum-chemical model of the nanostructure, but converged the calculation with a non-equilibrium "transporting" density from the Green's function formalism (NEGF), to calculate steady-state transport. Two interesting insights resulted:

1. While not a full model, it gets the major features of quantum transport qualitatively right, and I was able to extend it to get quantitatively close to experimental findings. The key insight was that the theory/experiment mismatch was largely caused by neglecting the metal/molecule-interface's role as a "mirror plane" for images of the partially-charged molecule. Correcting this renormalizes the level positions to yield much better agreement as suggested previously [10, 11], and shown by our team using a combination of theory and experiment[12, 13] (featured in a News & Views article [14]).
2. Taking this further, that transport can be calculated this way suggests that most of the interesting physics comes from the molecule and interface rather than the "deep" contacts. Those can be treated using quite simple (and cheap) methods, leaving computational resources directed at the rich local structure at the interface and on the molecule, for which a more detailed model should be taken[15].

This kind of work, combining ideas from the sciences, applied math, and algorithm design to tackle a problem with rich structure is why I am applying. Research and techniques at Santa Fe connect to my own future directions, and I feel that the combination of my academic background and practical experience would enrich the discussions.

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