Panel Discussion: Future Trends and Open Problems

The following is a *summary* of the panel discussion held at the end of the 8th Western Conference on Mathematical finance. What follows is *not* a transcript of the discussion. Text attributed to any given panelist should be considered a rough summary of what he/she said – *not* a quote.

Moderator: Tim Leung (TL).

Panelists: Jean-Pierre (JP) Fouque, Xin Guo (XG) and Mike Ludkovski (ML).

Opening Remarks:

JP: Systemic risk has changed the way we look at markets. Previous to the financial crises, we (i.e., financial mathematicians) would look at the risks faced by a single person, company or bank. Now, we look at risks of the entire financial system. There seem to be two major approaches to modeling these risks. One approach is to look at networks models of banks. The other approach is to look at the dynamics of interacting stochastic systems. Although we have now been looking at problems related to systemic risk for about a decade, this is still a new a developing area of research with many open problems and a lot of room for growth. The Office of Financial Research (OFR) has been formed and has 300+ works from different fields working there (economists, mathematicians, statasticians, computer scientists, etc.). One of the key duties of the OFR is to collect financial data. This is a difficult task, as we need to protect privacy laws while still allowing for the collection of *useful* data, which will enable us to design laws and regulations that protect the entire financial system.

XG: High-frequency and algorithmic trading is one area where we actually have a lot of data (if you can pay for it). Data comes on the millisecond time-frame. Management of this large quantity of data is an issue. A major challange for math finance is to learn a new language (i.e., now mathematical tools) for analyzing such large quantities of data. The "traditional" math finance skill-set of semimartingale modeling, stochastic control theory, and portfolio theory is not particularly well-suited to this new task. We need to learn to manipuate and understand data. Even though we may recognize the need to learn a new skill-set, another major challenge (for senior researchers) is how to advise students to do research in new and developing areas in which we do not have formal training. It will be essential for us to collaborate with people from Statisics, Computer Science, and Electrical Engineering, who can share with us and our students their areas of expertise (which may be more suited to analyzing data). Generally speaking, math finance researchers have to be open to new areas of research such as Big Data and Machine Learning. If we do not move into these areas, it will be difficult to attract talented young students, may of wome are interested in working for tech companies such as Google and Facebook, where Big Data and Machina Learning play a central Role.

ML: A major challenge is to re-orient our field form "traditional" mathematical finance to a broader class of problems. We should embrace the challenges in other fields. On one hand, we can learn from experts in other areas. But, at the same time, we should recognize that we have a strong training in probability theorey, stochastic analysis, and modeling of random systems. And we should recognize that our particular skill-set can bring something new to these hot new areas where financial mathematicians currently do not work.

TL: Indeed, one thing financial mathematicians are good at it is rigorously *proving* things. In Computer Science, for example, it is often sufficient to publish a new algorithm, test it on some data, and show via some numerical experiments that the new algorithm is faster or more accurate than some benchmark algorithm. At this point, and computer scientist might be satisfied. But a

financial mathematician would want to nail down precise conditions under which the new algorithm will beat the old benchmark. Perhaps bringing rigor to other fields is one way financial mathematicans can contribute.

Question: *What skills do companies in the financial industry people (e.g., Black Rock) look for in students these days?*

XG: Financial firms want students to have many of the same skills as that tech companies want students to have. For example, they might want students to know about data-mining (e.g., natural language processing). A major challange for the financial industry is that they are losing good students to tech companies. Young people feel like they can help society by working at Facebook and Google. By contrast, working in finance feels selfish so students do not do it.

JP: Well, it is not clear that one does more good for the world by working at Facebook, Google or Uber, than one does by working, e.g., for OFR.

Question: *Machine learning has been successful in tech (language processing). Have similar success stories appeared in finance?*

JP Yes. But, most of the success stories have come from hedge funds (i.e., Renaissance Technologies). Such hedge funds typically are very secretive and do not share information.

Question: *What is affect of smaller arbitrage opportunities in HF trading?*

XG: The High-Frequency trading industry is hiring even more. It is an arms race. Though, many of the new hires are moving to China, where there are more opportunities for arbitrage.