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The challenge of interdisciplinary research: a real-life story[*]

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Interdisciplinary research is a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice. This definition from the National Academies [1] can briefly explain the challenge of interdisciplinary research. In this post, I will tell you the benefits and obstacles I've experienced during my PhD training in Bioinformatics and Postdoc training in complex network. I hope graduate students find it interesting and helpful.

Interdisciplinary research requires student intensive background. It takes a longer time to gain skills, fill the gap between areas, and become mature in the field. I joined the bioinformatics lab for PhD project, which aims to develop software tools that can predict protein function based on their 3D structure information. Protein structure is a geometric object in three dimensional Euclid space. There are particular regions called functional sites in their structure that determine their functions. I need to compare a target protein, unknown function, to an extensive library of known function proteins from Protein Data Bank, to predict their functional sites. I've tried many techniques in Euclidean geometry, including 3D rotation, translation, geometric hashing, dynamic programming to compare local and global structures. Later on, I found graph theory more appropriate to model the structures and compare them. I think it is a success story when technical skills meet specific domain knowledge. To publish a software tool on the top-1 journal, you need to prove it better than the existing ones in terms of both computing time and accuracy. Furthermore, biologists have less expertise in technical, and usually require software with GUI that can run on all platforms Window, Unix, Linux, or Mac. Sufficient programming skills in both back-end and front end Java are needed.

A gap background between technical and biology is an issue. Even though, I can publish three software tools published in the top-1 journal, I felt obstacle to become mature and visible in the field. The domain knowledge in biology is vast. Technical is also very challenging because of the amount of biological data are increasing exponentially since the human genome project in 2001. While my colleagues and supervisor used the software tools I wrote every day, I didn't even know how to use them for a practical application as they did. Also, networking with experimental biologists are needed. They need your computational skills, but only they can validate your results.

The advantage is that the technical and quantitative backgrounds can be used for various research area domain. Instead of being consistent with biological research, I decided to switch to the financial field. I started with a quant job at a financial technology company. I have learned CFA level 1 and gained some algorithm trading strategies. The idea behind algorithm trading is that if I can find a price pattern with statistical significance, then I can code them into the automated trading application to make money. I have to back-test many trading strategies momentum, mean-reverting for the Forex market. Back-testing is the routine of trading simulations using historical price data. The simulation needs to be fair, no looking ahead, and survival bias taking into account the trading cost. I ended up with several promising trading strategies. However, none of them can beat the market and overcome the trading cost. The technical expertise is not enough. One should have a good domain knowledge in investment such as macro environment, long term stock value analysis, and investor behavior; and know how to include them into trading application. They are the keys for designing a successful trading strategy.

The most benefit of interdisciplinary research is that job and funding opportunities are huge. I met my current advisor and we applied Marie Sklodowska-Curie Individual Fellowship for my postdoc training. This distinguished fellowships are usually very competitive. However, my technical skills in network science meets his domain knowledge in financial research and we won the funding.

A gap background between technical and financial domain is an issue. We investigate investor behaviors. We model investors in the stock market using network theory. In an investor network, there is a link between two investors if the timing of their transactions is similar with statistical significance. An advantage is that network science methods are mature in system biology, and they can be used for other contexts. I usually borrowed methodologies from the biological field to solve the problem in financial research. However, applying them to a financial network context can be difficult. The difference is the domain interpretation and research question at hand. However, applying them to a financial network context can be difficult. The difference is the domain interpretation and research question at hand. For example, a gap between statistical models and the input data; and the correct domain interpretation for the model are issues. I don't have very good domain knowledge in financial research and investor behaviors. My previous experience in algorithmic trading does not help me much. It takes me much time to come up with the right research questions.

But it's not a real problem because I can lean them quickly and review the existing works. The most frustrated is that the gap between the network model and the data. We have a problem with sparse and low sample size data. For example, the investor networks need to be estimated for periods long enough, at least one year, to obtain statistically significant links. If we want to measure the correlation between the network structure and volatility estimated for the same periods, we should consider for a shorter time window because the market fluctuates drastically, and we should have sufficient data points for the regression model or correlation test. We encounter this low sample data when we estimate information transfer networks in the stock market. The idea is that investor A trade then share information for investor B that trade on the day after. If that happens for a sufficiently large number of times, or in other words, statistical significance, then we have a link in the network. One way to do it is to fit two trading vectors to the Vector Autoregressive model and estimate the statistical significance of coefficients. However, the stock market is much less liquid than the Forex one. We have a problem with sparse data. Trading vectors contain a lot of zero values because most individual investors trade not frequently. Fitting such vectors to VAR models return mostly statistical links while they are not. It can be partially solved by aggregating investors into investor groups based on their nature attribute. My colleagues had to suggest a more proper model for solving it.

Excellent writing skills are mandatory. I have been struggling with and enhancing my writing skills a lot. This is a significant gain in my postdoc training. Writing is a typical challenge for Vietnamese students. Especially, I spent too much time on technical works, but less on writing during PhD training. Furthermore, writing a paper in empirical finance is much different from a technical one. For example, instead of comparing one algorithm to another in terms of computing time and accuracy, we have to focus on empirical results and the economic and financial interpretation and meaning. I have learnt how to compromise both technical issues and empirical results in writing a paper.

In an academic environment, a gap in language and culture among people is an issue while collaboration is the crucial feature to be successful in disciplinary research. It is more likely that you will depend on the others for technical, specialized domain knowledge or data. Frequent interaction and communication are needed to get the tasks done. First, you must have excellent English skills and learn how to communicate technical problems efficiently. I have improved my English communication a lot, thanks to

my European colleagues. Also, people that have the same background and cultures tend to have more social communication and share information. International students from Asia often experience a culture gap in Europe. I am not an exception. The first honeymoon weeks in Europe is fascinating, and you might enjoy a different atmosphere of old continents: weather, architecture, European style. After that, You might feel confused and anxious to handle work and daily survival things. It can take you some time to imagine where you are and adjust to accept the culture. European are cultured and very nice. If you are active and ask them the right questions, they are pleased to help, and you will get the tasks done quickly.

Therefore, I think funding and career opportunities are huge for interdisciplinary research, and so are the challenges. Graduate students should be careful to choose a research direction and prepare themselves for higher education and future research.

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[1] Https://www.nationalacademies.org/.