Rafał Kulik, PhD
Department of Mathematics and Statistics
University of Ottawa
150 Louis Pasteur Pr., STM553
K1N 6N5 Ottawa, Ontario, Canada
rkulik@uottawa.ca

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Opinia o dorobku naukowym
doktora Marcina Pitery
w związku z postępowaniem habilitacyjnym
Rady Dyscypliny Matematyka
Uniwersytetu Jagiellońskiego

Marcin Pitera ukończył studia magisterskie na Uniwersytecie Jagiellońskim w 2010, pod kierunkiem dr. hab. Armena Edigariana. Otrzymał stopień doktora 25 czerwca 2015 roku na podstawie pracy *Selected problems on discrete time stochastic control for dynamic risk and performance measures*, obronionej na Wydziale Matematyki i Informatyki Uniwersytetu Jagiellońskiego, napisanej pod kierunkiem prof. dr hab. Łukasza Stettnera. W trakcie pisania doktoratu otrzymał stypednium Fundacji na rzecz Nauki Polskiej. Od 2014 jest zatrudniony w Instytucie Matematyki, Wydziału Matematyki i Informatyki Uniwersytetu Jagiellońskiego, od 2017 na stanowisku adiunkta.

Jako dorobek naukowy dr Pitera zaprezentował 9 prac na temat *Długookresowe problemy sterowania stochastycznego z kryterium wrażliwym na ryzyko oraz powiązane funkcje celu.* Prace zostały opublikowane w dobrych czasopismach takich jak *Stochastic Processes and their Applications*, *Mathematical Methods of Operations Research*, *Mathematical Finance*, *SIAM.* Siedem z tych prac napisanych jest wspólnie z promotorem pracy doktorskiej, prof. Stettnerem, niektóre z tych prac mają także dodatkowych autorów. Ten aspekt jest jedną z nielicznych słabszych stron dorobku naukowego - można by oczekiwać, że kilka prac pod doktoracie jest napisanych samodzielnie przez kandydata. Dwie pozostałe prace są napisane wspólnie z innymi badaczami. Dwie prace napisane są wspólnie z doktorantem (kolejny słabszy aspekt tej aplikacji). Wszystkie prace zostały napisane przez wnioskodawcę po uzyskaniu stopnia doktora. W dorobku naukowym znajduje się 18 innych prac, także opublikowanych w dobrych czasopismach takich jak *Electronic Journal of Statistics.*

Dorobek naukowy kandydata opiszę w języku angielskim. Niestety, nie znam w wielu przypadkach polskiej terminologii, a ten opis wymaga moim zdaniem dużej precyzji.

**Details of research contribution.** The research of the candidate deals with various aspects of a non-linear stochastic control.

- Article [H1] deals with optimization of

$$\varphi^{\gamma}(V) := \lim_{t\to\infty} \frac{1}{t}\frac{1}{\gamma} \ln \mathbb{E}[V_t^{\gamma}],$$

  where $V_t$ is an underlying portfolio value process. The function $\varphi^{\gamma}$ is called the Risk Sensitive Criterion. The optimization is carried over set $\mathcal{A}$, the set of all admissible portfolio strategies. The portfolio value process depends on these strategies as well as a factor process of Markovian-type. The key contribution of this paper is that the underlying Markov process is not necessarily bounded in the standard supremum norm. For this, the authors consider the weighted norm. However, there are quite strict conditions imposed such as geometric drift (which in turn leads to exponential mixing, under some additional conditions) and minorization.

- The optimization problem mentioned above is linked to existence of the solution to Bellman's equation. As such, in [H2] the candidate studies conditions for its existence. The authors provide minimal conditions for such existence. We note that Markovian framework is no longer considered.

- Article [H3] is an extension of [H1] to continuous-time framework. The authors consider the factor process to be a Feller-Markov process, still with strong drift and minorization assumptions. The supremum norm approach developed in [H1] is of a great help.

- Article [H4] is another one on the similar topic. In this article, the authors consider both discrete and continuous time framework, where the underlying factor process is again Feller-Markov. Unlike papers [H1]-[H3] (where the proofs are analytical), this paper is based on probabilistic considerations by calculating non-trivial bounds and conditional expectations.

- Even though [H4] considers both discrete and continuous time framework, there is no formal link between these two schemes. As such, the paper [H5] considers the discretized setting as an approximation to near-optimal strategies for the underlying continuous-time control problem. The techniques of this paper are similar to those of [H5].

  One can summarize that [H1]-[H5] deal with different flavours of the optimization problem related to $\varphi^{\gamma}(V)$ introduced above.

- Article [H6] deals with a different topic. The seminal paper of Arztner et al. provides axioms for risk measures. These risk measures are considered at one, particular time point (a static framework). The theory of static risk measures is relatively well understood. There are general approaches available on how to construct so-called coherent risk measures.

Since a portfolio is typically modelled as a stochastic process, a dynamic version of these risk measures has to be considered. Riedel (2004) added one additional axiom, time consistency. This property of dynamic risk measures was considered by several top researchers in the field of mathematical finance (Föllmer, Delbaen, Bielecki among others). The time consistency states that if $\rho_t(X) = \rho_t(Y)$ for some $t$, then the latter identity is valid for any $t$. Here, $\rho_t$ is the dynamic risk measure, while $X$ and $Y$ are random variables with the appropriate measurability. The question is: which dynamic risk measures are time consistent? Surprisingly, this topic has not been developed yet and the paper [H6] is one of the first step towards an axiomatic theory.

The main object of study are risk measures that are local and monotone in the sense of Definition 1. The latter property are foundational to obtain time-consistency. Several examples are given.

Besides risk measures, one is often interested in a performance of financial portfolio. For this, one needs to consider performance measures (acceptability indices). A seminal paper by Cherny and Madan (2004) proposes a set of normative axioms that a map must satisfy to be a good indicator of financial performance. A formal link between risk measures and acceptability indices was also established. As such, it is natural to consider a dynamic version of the acceptability indices and this is the second topic of the paper.

Unlike [H1]-[H5], this paper does not involve sophisticated analytical calculations, but is conceptual and foundational in nature.

- In [H7] the authors study the aforementioned acceptability indices in a static setting and show their link to other "measures" of financial performance (expected portfolio utility, risk-averse objective functions).

- Articles [H1]-[H7] are motivated primarily by the financial applications. Article [H8] is more general in nature. To be more specific, the authors consider existence of

$$\lim_{n\to\infty} \frac{\ln \mathbb{E}[\sum_{t=0}^{n-1} g(X_t) \mid X_0 = x]}{n},$$

where $X_t$ is a discrete-time Markov process and $g$ is a suitable function. Such problems were studied by Bielecki, Meyn, Stettner among others. Minorization and mixing are the fundamental assumptions that lead to an ergodic property. Many examples are given and links to financial applications are provided. The paper is technical in its nature.

- Finally, article [H9] (recently accepted) analyses stability another class of process, namely Markov Decision processes. Again, minorization and mixing play a crucial role.

**Summary of research contribution.** The articles are primarily of technical nature, with [H6] being an exception. The proofs involve techniques primarily from theory of Markov processes, differential equations, optimal stopping, risk measures. Each papers got between 10-20 citations (according to Google Scholar).

**Dodatkowe komentarze na temat dorobku naukowego.** Dr Pitera prezentował swoje osiągnięcia naukowe w czasie licznych konerencji i siminariów (w większości w kraju). Odbył kilka zagraniczncyh staży nauowych. Jest *Associate Editor* w dwóch czasopismach. Bierze też aktywny udział w organzizacji konferencji naukowych. Był wykonawcą w dwóch i glównym wykonawcą w jednym grancie NCN. Był (i jest) współpromotorem dwóch doktorantów.

Jak wspomniałem powyżej, w dorobku naukowym znajduje się 18 innych prac, dotykających różnych aspektów matematyki finansowej, zarówno probabilistycznych jak i statystycznych. To świadczy o bogatej wiedzy dr. Pitery: miary zależności i miary ryzyka, ich estymacja dla danych niezależnych jak i szeregów czasowych (GARCH).

**Konkluzja.** W mojej opinii, określone ustawowo "osiągnięcia naukowe" i dorobek naukowy doktora Marcina Pitery spełniają warunki stawiane Ustawą o tytule naukowym i stopniach naukowych. Popieram wniosek o nadanie stopnia doktora habilitowanego dr. Marcinowi Piterze.

Rafal Kulik