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Professor Jan Picek
Chair of the Habilitation Board
Charles University, Praha

Dear Professor Jan Picek,
hereby please find my report on the habilitation thesis submitted by Ing. Marek Omelka, Ph.D., titled

"*Nonparametric Estimation of Copulas, Conditional Copulas and Conditional Distribution Functions*".

The thesis is written within the general framework of Probability and Mathematical Statistics and, specifically, is devoted to the theory and the estimation of distribution functions with particular emphasis on copula-based models. It contains one introductive chapter and four chapters that describe the main scientific achievements. The thesis summarizes the results contained in five papers, written by Ing. Marek Omelka, Ph. D., in collaboration with Irène Gijbels (KU Leuven) and Noel Veraverbeke (Hasselt University). These papers appeared in journals of an excellent/very good international standard.
Chapter 2 focuses on kernel estimation of copulas. Contrarily to standard distribution functions, here the problem is that these distribution functions are supported on the unit hypercube and, hence, one encounters bias problems of the kernel estimators near the boundaries of the domain. To overcome these difficulties, a bandwidth shrinking function and a transformation estimator are suggested. Interestingly, it is proved that the suggested estimators have the same (first-order) asymptotic properties as an empirical copula function (see Theorem 2.2), but seem to perform better in finite samples. I also positively

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noticed in the last part of the chapter some discussion about possible ways to weaken furthermore the formulated assumptions.

Chapter 3 presents the nonparametric estimation of the conditional copula of a vector **Y** of random variables given a univariate covariate X. The main theoretical result is the weak convergence of the empirical copula process (see Theorems 3.1 and 3.2). Moreover, I appreciated the discussion of several practical issues that arise in the statistical practice and that need to be clarified in order to enhance the applied impact of the provided results.

Chapter 4 is related to the same setting of the previous chapter, but it assumes that the covariate X affects only the marginal distributions of the components of **Y**, but not the conditional dependence structure. This "simplifying assumption" is becoming very popular (and debated) in vine copula models also in view of its possible practical impacts. Roughly speaking, the main theoretical result is that, under this setting and some specific conditions, the asymptotic distribution of the copula estimator of C does not depend on the covariate (see Theorems 4.4 and 4.6). Practitioners should also read carefully the useful section 4.4 for some comments about "what happens if the pairwise simplifying assumption does not hold", as could be the case of many real situations.

When estimating a conditional copula one clearly needs to estimate conditional (marginal) distribution functions. In particular, a good nonparametric estimator of the conditional distribution functions usually improves the sample properties of conditional copulas. Also from this motivation, chapter 5 deals with non-parametric estimation of a conditional distribution function. It suggests a method of preadjusting the original observations non-parametrically through location and scale, in order to reduce the bias of the estimator. Asymptotic properties are also shown. Interestingly, it is discussed how the idea of the preadjusting could be fruitfully considered in other settings such as conditional quantile and density estimation.

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All the chapters have some aspects in common. First, all results embrace a non-parametric approach. Second, they discuss in depth the main assumptions of the given results clarifying both their mathematical significance and possible limitations in the standard practice. Third, large simulation study are performed in order to check the finite sample performance of the proposed methodologies and, in many cases, to make comparisons with existing methods. Finally, real case studies show the practical relevance of the novel achievements.
Through the scientific work summarized in this thesis, Ing. Marek Omelka, Ph. D., has shown that he can conduct innovative research at a high international level, with visibility to broader research community and with the potential of begin applied to various fields. The research questions treated are topical and of interest to a large community. The thesis is very well written and stimulates further interesting research questions.
In view of these elements, I warmly recommend the habilitation board to appoint Ing. Marek Omelka, Ph. D., as Associate Professor.

Lecce, September 9th, 2017

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