

## SELF-NORMALIZED LARGE DEVIATIONS

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Let  $\{X, X_n, n \geq 1\}$  be a sequence of independent and identically distributed random variables. The classical Cramér–Chernoff large deviation states that  $\lim_{n \rightarrow \infty} n^{-1} \ln P(\sum_{i=1}^n X_i)/n \geq x) = \ln \rho(x)$  if and only if the moment generating function of  $X$  is finite in a right neighborhood of zero. This paper uses  $n^{(p-1)/p} V_{n,p} = n^{(p-1)/p} (\sum_{i=1}^n |X_i|^p)^{1/p}$  ( $p > 1$ ) as the normalizing constant to establish a self-normalized large deviation without any moment conditions. A self-normalized moderate deviation, that is, the asymptotic probability of  $P(S_n/V_{n,p} \geq x_n)$  for  $x_n = o(n^{1/(p-1)})$ , is also found for any  $X$  in the domain of attraction of a normal or stable law. As a consequence, a precise constant in the self-normalized law of the iterated logarithm of Griffin and Kuelbs is obtained. Applications to the limit distribution of self-normalized sums, the asymptotic probability of the  $r$ -statistic as well as to the Erdős–Rényi–Shepp law of large numbers are also discussed.

1. Introduction. Throughout this paper, let  $(\Omega, \Sigma, P)$  denote a probability space, and let  $\{X, X_n, n \geq 1\}$  be a sequence of independent and identically distributed (i.i.d.) nondegenerate real-valued random variables on the probability space. Put

$$S_n = \sum_{i=1}^n X_i, \quad V_n^2 = \sum_{i=1}^n X_i^2, \quad n = 1, 2, \dots$$

The classical Cramér–Chernoff large deviation [Chernoff (1952)] states that if

$$(A) \quad E e^{t_0 X} < \infty \text{ for some } t_0 > 0,$$

then for every  $x > EX$ ,

$$\lim_{n \rightarrow \infty} n^{-1} \ln P\left(\frac{S_n}{n} \geq x\right) = \ln \rho(x),$$

or equivalently,

$$(1.1) \quad \lim_{n \rightarrow \infty} P\left(\frac{S_n}{n} \geq x\right)^{1/n} = \rho(x),$$

where  $\rho(x) = \inf_{t \geq 0} e^{-tx} E e^{tX}$ .

Roughly speaking, this type of large deviation shows that the convergence rate in the law of large numbers is exponential if the moment generating

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# Chapter 3 Self Normalized Large Deviations

**Victor H. Peña, Tze Leung Lai, Qi-Man  
Shao**



### Chapter 3 Self Normalized Large Deviations:

**Self-Normalized Processes** Victor H. Peña, Tze Leung Lai, Qi-Man Shao, 2008-12-25 Self-normalized processes are of common occurrence in probabilistic and statistical studies. A prototypical example is Student's  $t$  statistic introduced in 1908 by Gosset whose portrait is on the front cover. Due to the highly non-linear nature of these processes, the theory experienced a long period of slow development. In recent years, there have been a number of important advances in the theory and applications of self-normalized processes. Some of these developments are closely linked to the study of central limit theorems which imply that self-normalized processes are approximate pivots for statistical inference. The present volume covers recent developments in the area including self-normalized large and moderate deviations and laws of the iterated logarithms for self-normalized martingales. This is the first book that systematically treats the theory and applications of self-normalization. *Asymptotic Theory in Probability and Statistics with Applications* T. L. Lai, Lianfen Qian, Qi-Man Shao, 2008. Presents a collection of 18 papers, many of which are surveys on asymptotic theory in probability and statistics with applications to a variety of problems. This volume comprises three parts: limit theorems, statistics and applications, and mathematical finance and insurance. It is suitable for graduate students in probability and statistics. **Probability Theory and Mathematical Statistics** B. Grigelionis, J. Kubilius, V. Paulauskas, H. Pragarauskas, R. Rudzkiš, V. Statulevičius, 2020-05-05. No detailed description available for Probability Theory and Mathematical Statistics.

**Asymptotic Theory of Statistics and Probability** Anirban DasGupta, 2008-02-06. This book developed out of my year-long course on asymptotic theory at Purdue University. To some extent, the topics coincide with what I cover in that course. There are already a number of well-known books on asymptotics. This book is quite different. It covers more topics in one source than are available in any other single book on asymptotic theory. Numerous topics covered in this book are available in the literature in a scattered manner and they are brought together under one umbrella in this book. Asymptotic theory is a central unifying theme in probability and statistics. My main goal in writing this book is to give its readers a feel for the incredible scope and reach of asymptotics. I have tried to write this book in a way that is accessible and to make the reader appreciate the beauty of theory and the insights that only theory can provide. Essentially every theorem in the book comes with at least one reference preceding or following the statement of the theorem. In addition, I have provided a separate theorem by theorem reference as an entry on its own in the front of the book to make it extremely convenient for the reader to find a proof that was not provided in the text. Also particularly worth mentioning is a collection of nearly 300 practically useful inequalities that I have collected together from numerous sources. This is appended at the very end of the book. **The Annals of Statistics**, 2007. *Mathematical Reviews*, 2007. **Bulletin of the Academy of Sciences of the USSR. Akademii nauk SSSR.**, 1983. *Current Index to Statistics, Applications, Methods and Theory*, 1998. The Current Index to Statistics (CIS) is a bibliographic index of publications in statistics, probability, and related fields. **Journal of the American**

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IEEE Conference on Decision and Control ,1987      The Fractal Approach to Heterogeneous Chemistry D. Avnir,1989-06-16  
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