Theory of Probability and Mathematical Statistics

Number 109 2023





Taras Shevchenko National University of Kyiv

THEORY OF PROBABILITY AND MATHEMATICAL STATISTICS

Editorial Board

Yu. S. Mishura (Editor-in-Chief)M. M. Leonenko (Deputy Editor-in-Chief)K. V. Ralchenko (Managing Editor)

| V. V. Anisimov | I. Molchanov |
|----------------|------------------|
| A. Ayache | A. A. Novikov |
| T. Bodnar | O. Okhrin |
| M. Dozzi | A. Ya. Olenko |
| M. Grothaus | E. Orsingher |
| A. Iksanov | F. Polito |
| A. V. Ivanov | D.S. Silvestrov |
| M. M. Leonenko | G. M. Shevchenko |
| R. Maiboroda | Tommi Sottinen |
| A. Malyarenko | A. Swishchuk |
| A. Marynych | A. Volodin |
| L. Mattner | O. K. Zakusylo |

SUBMISSION INFORMATION. All submissions to the journal should be sent to journal.tims@gmail.com. For more information see http://probability.univ.kiev.ua/tims/.

SUBSCRIPTION INFORMATION. The 2023 subscription is for Numbers 108 and 109.

Note: Starting with Issue 102, the *Theory of Probability and Mathematical Statistics* is published jointly by Taras Shevchenko National University of Kyiv and the American Mathematical Society as the original English-language journal.

Subscription prices for 2023 are as follows:

Paper format with free electronic access: List: US\$1086.00; **Electronic only**: List: US\$1032.00. Upon request, subscribers to paper delivery of this journal are also entitled to receive electronic delivery. Subscription renewals are subject to late fees. See www.ams.org/journal-faq for more journal subscription information.

BACK NUMBER INFORMATION. For back issues see www.ams.org/backvols.

Subscriptions and orders should be addressed to American Mathematical Society, P.O. Box 845904, Boston, MA 02284-5904, USA. *All orders must be accompanied by payment*. Other correspondence should be addressed to 201 Charles Street, Providence, RI 02904-2213, USA.

COPYING AND REPRINTING. Individual readers of this publication, and nonprofit libraries acting for them, are permitted to make fair use of the material, such as to copy an article for use in teaching or research. Permission is granted to quote brief passages from this publication in reviews, provided the customary acknowledgment of the source is given.

Republication, systematic copying, or multiple reproduction of any material in this publication is permitted only under license from the American Mathematical Society. Requests for permission to reuse portions of AMS publication content are handled by the Copyright Clearance Center. For more information, please visit www.ams.org/publications/pubpermissions.

Excluded from these provisions is material in articles for which the author holds copyright. In such cases, requests for permission to use or reprint should be addressed directly to the author(s). (Copyright ownership is indicated in the notice in the lower right-hand corner of the first page of each article.)

Theory of Probability and Mathematical Statistics (ISSN 0094-9000) is published by Taras Shevchenko National University of Kyiv, Ukraine, and the American Mathematical Society, 201 Charles Street, Providence, RI 02904-2213, USA and is mailed from Providence, Rhode Island. Postmaster: Send address changes to Theory of Probability and Mathematical Statistics, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2213, USA.

© 2023, Taras Shevchenko National University of Kyiv. All rights reserved.

This journal is abstracted/indexed in SCOPUS[®], Web of Science Core Collection, Zentralblatt Math, Mathematical Reviews, Statistical Methods and Applications,

and Google Scholar.

This journal is archived in *Portico* and in *CLOCKSS*.

Printed in the United States of America.

 \otimes The paper used in this journal is acid-free and falls within the guidelines

established to ensure permanence and durability.

10 9 8 7 6 5 4 3 2 1 28 27 26 25 24 23

Theory of Probability and Mathematical Statistics

Number 109 2023



American Mathematical Society

Providence, Rhode Island USA



Taras Shevchenko National University of Kyiv

THEORY OF PROBABILITY AND MATHEMATICAL STATISTICS

Editorial Board

Yu. S. Mishura (Editor-in-Chief)M. M. Leonenko (Deputy Editor-in-Chief)K. V. Ralchenko (Managing Editor)

| V. V. Anisimov | I. Molchanov |
|----------------|------------------|
| A. Ayache | A. A. Novikov |
| T. Bodnar | O. Okhrin |
| M. Dozzi | A. Ya. Olenko |
| M. Grothaus | E. Orsingher |
| A. Iksanov | F. Polito |
| A. V. Ivanov | D.S. Silvestrov |
| M. M. Leonenko | G. M. Shevchenko |
| R. Maiboroda | Tommi Sottinen |
| A. Malyarenko | A. Swishchuk |
| A. Marynych | A. Volodin |
| L. Mattner | O. K. Zakusylo |

SUBMISSION INFORMATION. All submissions to the journal should be sent to journal.tims@gmail.com. For more information see http://probability.univ.kiev.ua/tims/.

SUBSCRIPTION INFORMATION. The 2023 subscription is for Numbers 108 and 109.

Note: Starting with Issue 102, the *Theory of Probability and Mathematical Statistics* is published jointly by Taras Shevchenko National University of Kyiv and the American Mathematical Society as the original English-language journal.

Subscription prices for 2023 are as follows:

Paper format with free electronic access: List: US\$1086.00; **Electronic only**: List: US\$1032.00. Upon request, subscribers to paper delivery of this journal are also entitled to receive electronic delivery. Subscription renewals are subject to late fees. See www.ams.org/journal-faq for more journal subscription information.

BACK NUMBER INFORMATION. For back issues see www.ams.org/backvols.

Subscriptions and orders should be addressed to American Mathematical Society, P.O. Box 845904, Boston, MA 02284-5904, USA. *All orders must be accompanied by payment*. Other correspondence should be addressed to 201 Charles Street, Providence, RI 02904-2213, USA.

COPYING AND REPRINTING. Individual readers of this publication, and nonprofit libraries acting for them, are permitted to make fair use of the material, such as to copy an article for use in teaching or research. Permission is granted to quote brief passages from this publication in reviews, provided the customary acknowledgment of the source is given.

Republication, systematic copying, or multiple reproduction of any material in this publication is permitted only under license from the American Mathematical Society. Requests for permission to reuse portions of AMS publication content are handled by the Copyright Clearance Center. For more information, please visit www.ams.org/publications/pubpermissions.

Excluded from these provisions is material in articles for which the author holds copyright. In such cases, requests for permission to use or reprint should be addressed directly to the author(s). (Copyright ownership is indicated in the notice in the lower right-hand corner of the first page of each article.)

Theory of Probability and Mathematical Statistics (ISSN 0094-9000) is published by Taras Shevchenko National University of Kyiv, Ukraine, and the American Mathematical Society, 201 Charles Street, Providence, RI 02904-2213, USA and is mailed from Providence, Rhode Island. Postmaster: Send address changes to Theory of Probability and Mathematical Statistics, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2213, USA.

© 2023, Taras Shevchenko National University of Kyiv. All rights reserved.

This journal is abstracted/indexed in SCOPUS[®], Web of Science Core Collection, Zentralblatt Math, Mathematical Reviews, Statistical Methods and Applications,

and Google Scholar.

This journal is archived in *Portico* and in *CLOCKSS*.

Printed in the United States of America.

 \otimes The paper used in this journal is acid-free and falls within the guidelines

established to ensure permanence and durability.

10 9 8 7 6 5 4 3 2 1 28 27 26 25 24 23

CONTENTS

| 1 |
|-----|
| |
| 3 |
| |
| 37 |
| |
| 55 |
| |
| 81 |
| |
| 101 |
| |
| |
| 129 |
| |
| 159 |
| |





www.univ.kiev.ua/en/



