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Editorial Office
Proceedings of the National Academy of Sciences
500 Fifth Street NW
Washington, DC 20001

Dear Editors,

We are pleased to submit our manuscript entitled “**Voter Turnouts Govern Key Electoral Statistics**” for consideration as a Brief Report in the *Proceedings of the National Academy of Sciences*.

Summary of Findings: Our study reveals a fundamental and previously unrecognized role of voter turnout in determining key electoral statistics. Using empirical data from 12 countries spanning multiple decades, we demonstrate that the voter turnout distribution—combined with the effective number of candidates—is sufficient to accurately predict the scaled vote distributions of election winners and runners-up. This result holds universally across diverse electoral systems and scales, from large parliamentary constituencies ($\sim 10^5\text{--}10^6$ voters) down to individual polling booths ($\sim 10^2\text{--}10^3$ voters).

Why PNAS: We believe this work is well-suited for PNAS for several reasons:

- **Broad Scientific Significance:** Elections are universal institutions in democratic societies, yet the quantitative relationships governing their outcomes remain poorly understood. Our findings establish voter turnout as a diagnostic metric with predictive power far exceeding its conventional interpretation as merely an indicator of public interest.
- **Interdisciplinary Appeal:** This work bridges statistical physics, political science, and complex systems research. The Random Voting Model (RVM) framework we employ connects theoretical predictions with empirical observations across vastly different political contexts.
- **Practical Implications:** Our results suggest new directions for diagnosing election integrity. If turnout distributions encode predictable information about vote distributions in fair elections, deviations from these predictions could serve as forensic indicators of electoral irregularities—a finding with direct policy relevance.
- **Rigorous Validation:** We validate our results through three independent approaches: extensive empirical analysis, numerical simulations using the Random Voting Model, and analytical derivations in the large-turnout limit.

Relationship to Prior Work: This manuscript builds upon our earlier work establishing universal patterns in victory margin distributions [R. Pal, A. Kumar, and M. S. Santhanam, Phys. Rev. Lett. **134**, 017401 (2025)]. The present study significantly extends those findings by demonstrating that

turnout distributions govern not just margins but the complete vote distributions of winners and runners-up.

Author Contributions: All authors developed the conceptual framework. R.P. performed the theoretical calculations, data collection, data analysis, and simulations. A.K. performed theoretical calculations and analyzed insights. M.S.S. supervised the project. All authors contributed to writing the manuscript.

Conflicts of Interest: The authors declare no competing interests.

Data Availability: All election data used in this study are publicly available from official government election commissions and established repositories. Code and processed datasets will be made available upon publication.

We confirm that this manuscript has not been published elsewhere and is not under consideration by another journal. All authors have approved this submission.

We suggest the following PNAS categories: *Applied Physical Sciences* and *Social Sciences* (Political Sciences).

Thank you for considering our manuscript. We look forward to your response.

Sincerely,

Ritam Pal

On behalf of all authors